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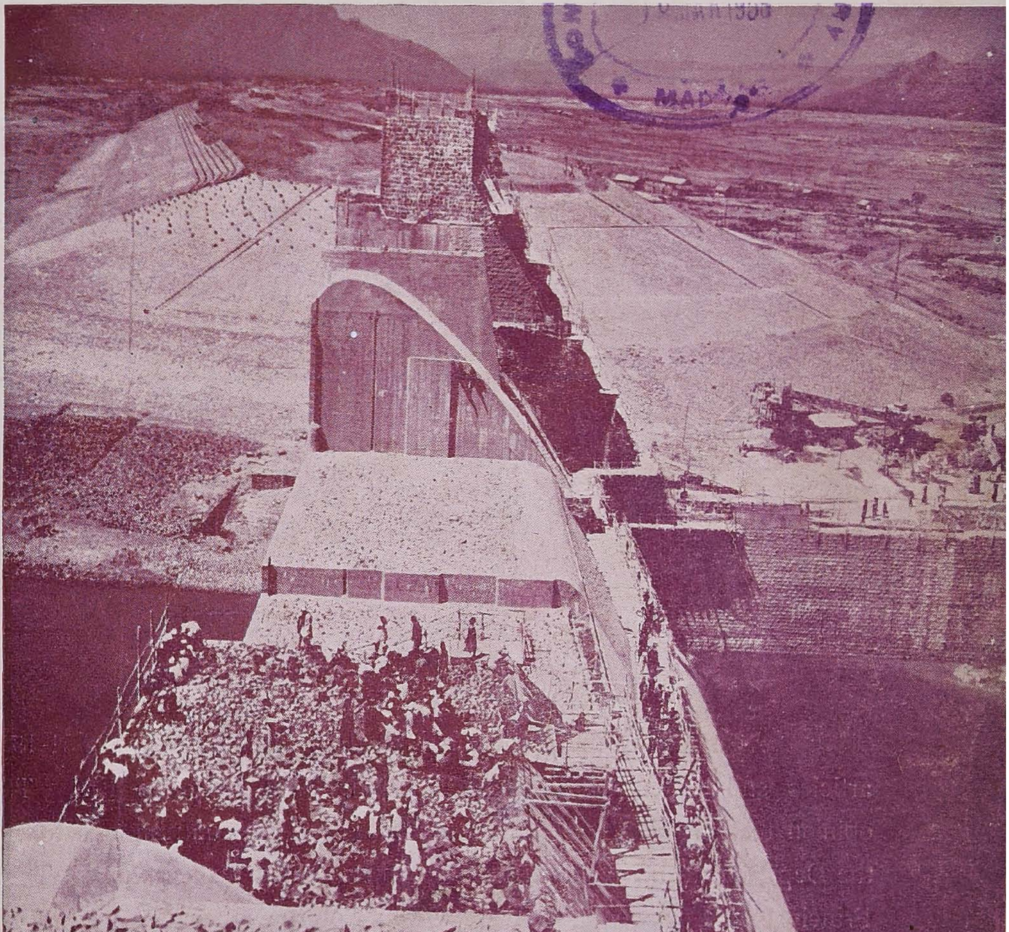

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OUR FRONT COVER

LOWER BHAVANI DAM UNDER CONSTRUCTION

A gravity masonry cum earthen Dam is nearing completion across the Bhavani at Bhavanisagar, 23 miles from Mettupalayam. The Project is intended to benefit mainly a portion of the Coimbatore District and a little portion of the Tiruchirapalli District after meeting the requirements of the existing irrigation The masonry portion of the Dam is built of stone in cement mortar while the earthen portion of the Dam is made up of rolled earth fill of tested quality.

The following are the salient features of the Dam :

Full Reservoir Level	+ 915
Top of Dam	.. + 930
Crest of Spillway	.. + 900
Height of Dam over deepest foundations	.. 204 feet
Total length of masonry dam	.. 1,523 feet
Length of spillway in masonry dam	.. 396 feet
Total length of earthen dam	.. 27,877 feet
Size and No. of spillway gates	.. 9 Nos. of 36' x 15' each
Contents of masonry dam	.. 14 M.C Ft.
Contents of earthen dam	.. 161 M.C Ft
Area of reservoir water spread	.. 30 Sq miles
Capacity of reservoir at F.R.L.	.. 27,460 M.C. Ft
Catchment area of river at dam site	1,621 sq. miles
Maximum flood discharge provided for	.. 1,20,000 cusecs
Crops proposed	.. Mainly irrigated dry

The photo shows portions of the spillway raised to the crest level of + 900, the completed bulk-head section and the earthen dam under construction in the left flank

CONTRIBUTIONS INVITED.

Attention of the readers is invited to Circular No. 392/51-195 dated 26-11-1952 inviting articles and papers for publication in the New Irrigation Era. The Chief Engineer is of the opinion that in spite of appeals and invitations, the contributions to the journal by the Officers of the Department and others have been much below expectations. The Officers of the Department, Principals of Engineering Colleges, Officers of the sister Engineering Departments in the State and others interested in the Science and Development of Irrigation are requested to contribute articles and papers in very good numbers.

For 'Instructions to Contributors' reference is invited to pages 245, 246, 247, 248 of Volume II.

THE NEW IRRIGATION ERA

Published by the Irrigation Branch of the Madras Public Works Department, Madras (5) South India.

(For Departmental Circulation only)

" I believe in Hands that work,
Brains that think and
Hearts that love."

—Elbert Hubbard.

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METHODS TO SPEED CONSTRUCTION AND LOWER COSTS.

1 Permit the contractor free use of new types of equipment.

2. Be sure land is available and the job ready for the contractor to move in and start work when bids are opened.

3. Use local construction materials to a maximum. (This will also reduce the cost of materials.)

4. Prepare designs that will permit maximum use of the splendid construction equipment now available.

5. Cut hand labour to a minimum.

6. Award programmes in contracts of various sizes.

7. Greater standardization of design so as to obtain savings, in the use of forms, centerings and equipments, and secure economies of repeat work, for example, through the use of the same type of bridge forms in neighbouring states.

8. Use specifications without revision for as long a period as feasible and practicable; that is, do not change the general specifications each year, and when they are revised, obtain the contractor's suggestions by contacting his organization.

9. Make the specifications of neighbouring states as uniform as possible. Contractors see no need for one state to specify that all batches of concrete be mixed for at least two minutes in one state while a neighbouring state specifies a one minute minimum mixing period.

10. Utilize to the fullest extent each year's construction season so as to permit maximum use of the contractor's equipment and personnel, and thereby get better prices.

11. Endeavour to set up a balanced construction programme. For example, if a highway department schedules a large volume of black-top work for one year and none the next, it will be difficult for the construction industry, to keep in step, and higher prices will result.

12. Pay the contractor frequently and promptly for completed work and reduce to a minimum the retained percentage on partial payments; the financial responsibilities of the contractor are extensive, and if he has to pay interests to a bank, he transfers it to you adding to overheads.

—Adapted with modifications from "Civil Engineering,' September 1952.

EDITORIAL

DEMOCRACY AND PLANNING

● THE term "Planning" has been used in so many different senses in the past that the nomenclature has even come to be a source of some confusion. A proper synonym for "Planning" would be "Unified Resource Development." The idea of unified resource development is based on the premise that by democratic planning the individual's interest, the interest of private undertakings, can increasingly be made one with the interest of all of us, *i.e.*, the community interest.

● EFFECTIVE planners understand and believe in the people. The average man should be constantly in the mind of the effective planning expert. Planners whether they are technicians or administrators must recognise that they are not dealing with philosophical abstractions, or mere statistics or engineering data, or legal principles, and that planning is not an end in itself. In the last analysis, in democratic planning it is human beings we are concerned with. Unless plans show an understanding and recognition of the aspirations of men and women, they will fail.

P. T. O.

●HERE is the life principle of democratic planning—*an awakening in the whole people of a sense of common moral purpose.* Not one goal, but a direction. Not one plan once and for all, but the conscious selection by the people of successive plans. The people must be in on the planning: their existing institutions must be made part of it. Self education of the citizenry is more important than specific projects or physical changes.

●PLANS and action are part of one responsibility. The results depend chiefly on the peoples' participation. Getting participation should be almost wholly on a voluntary basis. The reliance should be upon methods of persuasion, incentives, encouragement,—methods based on the peoples' confidence in the planners' comprehension, their good faith, and the quality of their technical leadership. The limitations of voluntary methods, distressing and tragic as their consequences sometimes are, do not invalidate the wisdom of a minimum of coercion in carrying out plans for resource development.

Tests on 'A' Class Hume Pipes.

J. E. VAZ, B.E.,
Executive Engineer, P. W. D., Malampuzha Canals Division, Palghat.

1. **Introduction** :— The Malampuzha Left Main Canal intercepts a large number of small drainage courses and valleys where undertunnels are essential. The possibilities of utilising Hume Pipes for evolving a cheap design had to be explored. It was thought that utilization of "A" Class Hume Pipes, which are readily available, would result in savings in cost and quickness in execution. However, the safe permissible loading on "A" Class Pipes had to be determined first and it was considered prudent to carry out some tests as reliable data on the subject was not available with the department. The following three tests were therefore conducted in the Malampuzha Canals Division on "A" Class Pipes of 3'-0" internal diameter. The sketches referred to in the tests are given in Annexure 1. A statement showing the comparative costs of some typical barrels is given in Annexure 3 for guidance.

2 **Test No. 1** :— *Hume pipe loaded with an embankment of sand. Date of Test 24-2-51 and 3-3-51.*

(i) "A" Class Hume Pipe of internal diameter 3'-0", free from cracks, was selected and laid horizontally on a good sandy bed. It was loaded with an embankment of sand as shown in sketches A, B and C (vide Annexure 1). Sand bag retaining walls were formed at the toe and ends for retaining the sand filling. The sand filling was done in 6" layers, well rammed. Two pipes were tested with sand embankment as shown in the sketches.

(ii) Both the pipes developed longitudinal cracks at the top and bottom when the height of embankment over the pipe was 5'-0". Loading was continued up to 6'-0" and the cracks started widening. The cracks develop from the inside of the pipes being prominent on the inside and hardly perceptible on the outside. The cracks occur more or less at the top and bottom and run longitudinally from one end to the other in a zig-zag line.

3. **Test No. 2** :—*Load Test on Hume Pipe encased in plain concrete.*

(i) "A" Class Hume Pipe, 3' diameter and 8' long, free from cracks, was laid over a bed of cement concrete 1:5:10, one foot thick and the pipe was encased in plain concrete 1:5:10, 1'-6" thick at sides and 1'-0" at top, as indicated in sketch (D).

(ii) Over the top of the concrete, tram rails were stacked side by side in rows, alternate rows being at right angles to each other. On top of these rails sand bags were stacked. Up to a load of 76 tons distributed over an area of 8'-0"×6'-4" of the concrete no crack was noticed either in the pipe or in the concrete casing. This loading is equivalent to a load of 26.9 feet height of earthen bank, assuming 125 lbs weight per c. ft. of earth.

(iii) When a further load of 3,915 lbs was applied, cracks began to appear at the top and bottom of the pipe and also in the top concrete (at the ends). When another 3,915 lbs of load was applied, the cracks at the top and bottom of the pipe developed longitudinally to the full length and the crack in the top concrete developed to the full depth. The exact positions of the cracks are shown in sketches (E) and (F).

(iv) *Details of Loading* :—

Concrete was laid on 16—3—1951

Load Test commenced on 30—3—1951, and completed on 28—4—1951.

Note :—**Load is assumed to be distributed over 8'-0" × 6'-4".**

Earth is assumed to weigh 125 lbs per c. ft.

Average weight of sand bag=87 lbs.

Date.	Load	Weight lbs.	Progressive total of load.		Equivalent height of earthen bank over tunnel.	Remarks.
			lbs.	Tons.		
30–3–51	494 Nos. rails, 18′ long and 20 lbs/yd. ...	59,280	59,280	26.5	9.4 ft.	No cracks
31–3–51	103 Nos. rails, 18′ long and 20 lbs/yd. ...	12,360	71,640	32.0	11.3 ft.	do
10–4–51	547 Nos. sand bags 87 lbs. each ...	47,589	1,19,229	53 2	18.8 ft.	do
11–4–51	64 Nos. sand bags 87 lbs each ...	5,568	1,24,797	55.7	19.7 ft.	do
21–4–51	110 Nos. sand bags 87 lbs. each ...	9,570	1,34,367	60 0	21.2 ft.	do
22–4–51	204 Nos. sand bags 87 lbs. each ...	17,748	1,52,115	67.9	24.0 ft.	do
27–4–51	210 Nos. sand bags 87 lbs. each ...	18,270	1,70,385	76.0	26.9 ft.	No crack in pipe or concrete.
28–4–51	45 Nos. sand bags 87 lbs. each ...	3,915	1,74,300	77.8	27.5 ft.	Pipe and concrete showed cracks at ends.
28–4–51	45 Nos. sand bags 87 lbs. each ...	3,915	1,78,215	79.6	28.1 ft.	Cracks developed in pipe longitudinally at top and bottom. Crack in top concrete well defined at ends

Positions of cracks are shown in sketches (E) and (F).

4. Test No 3:—*Load Test on Hume Pipe partly encased in concrete 1 : 5 : 10 and partly in R. C. 1:2:4.*

(i) 'A' Class Hume Pipe, 3′ diameter and 8′ long, free from cracks was laid over a bed of concrete 1 : 5 : 10, 1′-0″ thick and encased in concrete and R. C. as shown in sketch (G).

(ii) The loading was done with rails and sand bags. But owing to the curved surface of the R. C. encasement there was some practical difficutly in distributing the load evenly on the top of the pipe. However, the load was distributed in the best way possible by means of a wooden frame kept on top of the pipe as shown in sketch (H). This frame gave a horizontal bedding for the load and this load was distributed as best as possible by sand filling inside the frame.

(iii) *Details of loading*:—

Concrete was laid on 17—3–51.

Load Test Commended on 4–5—1951 and was completed on 5–5—51.

Loading was done in the same way as in the previous case with rails and sand bags.

Note :—The load is assumed to be distributed over 8′-0″ × 4′-6″ and not over the area of the frame alone.

Earth is assumed to weigh 125 lbs. per c.ft.

Average weight of sand bag=87 lbs.

Date.	Load.	Weight lbs.	Progressive total of load.		Equivalent height of earthen bank over tunnel.	Remarks.
			lbs.	Tons.		
4—5—51	497 Nos. rails, 18′ long & 20 lbs/yd.	59,640	59,640	26.6	13.30 ft.	
5—5—51	150 Nos. sand bags each weighing 87 lbs.	13,050	72,690	32.5	16.1 ft.	No crack in pipe or concrete
5—5—51	80 Nos. sand bags each, 87 lbs.	6,960	79,650	35.6	17.7 ft.	Pipe and concrete started cracking.

The crack first started in the R. C. casing and then in the pipe.

The positions of the cracks are shown in sketch (I).

5. Conclusions :—

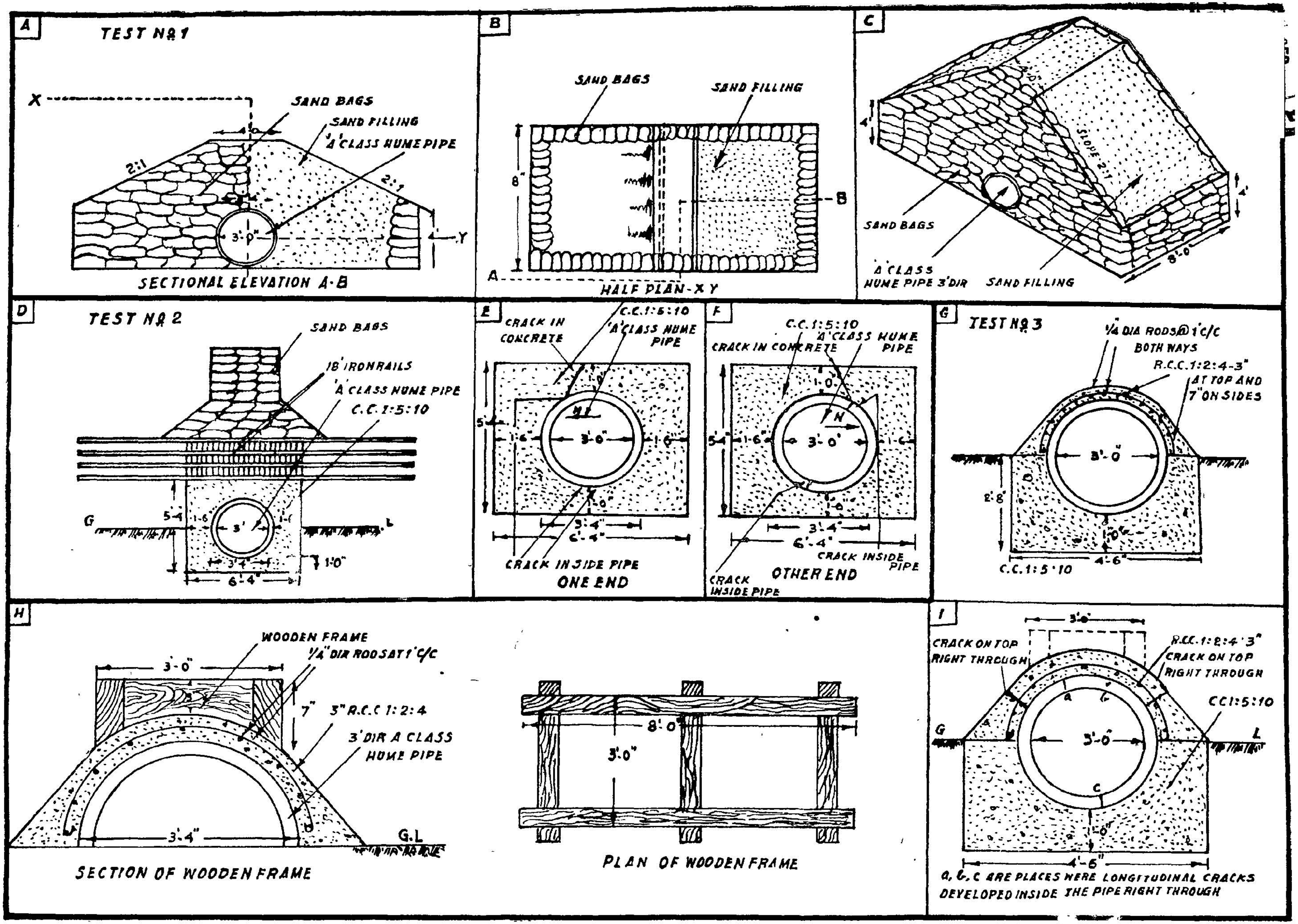
(i) *Test No. 1* :—was conducted to determine the possibilities of using "A" Class Hume Pipes under low embankment for cross Drainage Works and Sluices without any additional external reinforcement. Since sand is a cohesionless medium it will be possible for the pipe to withstand slightly higher pressure when used under earthen banks where there will be dispersion of load owing to arch action. A bed of concrete at the bottom and collars at the joints will give some additional strength to the pipes. However, even under the most favourable conditions, a 3′-0″ diameter, "A" Class Pipe is safe upto maximum height of only 6′-0″ of earthfill as may be noticed from the circular dated 25—8—37 from the Indian Hume Pipe Co., Ltd. This circular of the manufacturers is reproduced as Annexure (2) for information and guidance. It will be noticed that lightly reinforced, untested "A" Class Pipes of the larger sizes are actually not as safe as they would appear and therefore have to be used with caution for Irrigation Works.

(ii) *Test No. 2* :—was conducted to determine the possibilities of using "A" Class Pipes for undertunnels by suitably strengthening them with lean concrete all round. The type of tunnels is considered quite suitable for banks within 15′ height. The joints need not be provided with collars and the construction work is quick and does not present any practical difficulty. But if economy is the criterion, a tunnel with arched or R. C. roof will be cheaper. Where speed is required in execution this type of tunnel is considered suitable.

(iii) *Test No. 3* :—was conducted to determine the possibilities of reinforcing the pipes in a cheaper way than in Test 2. This type of reinforcement is no doubt cheaper, but in practice it is difficult to do the top encasement satisfactorily. Moreover the test result shows that this type of tunnel is not suitable for high embankments.

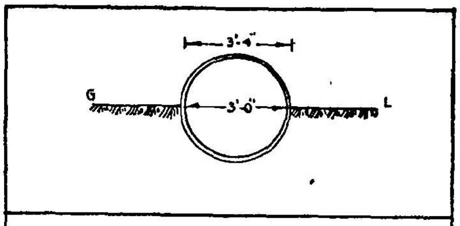
(iv) In all the pipes that were tested it was noticed that the failure in the pipe occurs at the top and bottom and the cracks develop from the inside of the pipe, as actually seen at the ends of the pipe. This indicates that when the top and bottom of the pipe act as arches the haunches are not rigid enough and the pipe tends to become an ellipse with the major axis in the horizontal direction, resulting in tension on the inner face where the failure occurs. If lateral

ANNEXURE 1


A
TEST No. 1
SAND BAGS
SAND FILLING
'A' CLASS HUME PIPE
2:1
2:1
3'-0"
SECTIONAL ELEVATION A-B
B
SAND BAGS
SAND FILLING
8'
HALF PLAN - X Y
C
SLOPE 2:1
4'
4'
8'-0"
SAND BAGS
'A' CLASS HUME PIPE 3' DIA
SAND FILLING
D
TEST No. 2
SAND BAGS
18' IRON RAILS
'A' CLASS HUME PIPE
C.C. 1:5:10
5'-4"
1'-6"
3'
1'-6"
3'-4"
6'-4"
1'-0"
G
L
E
CRACK IN CONCRETE
C.C. 1:5:10
'A' CLASS HUME PIPE
3'-0"
3'-4"
6'-4"
CRACK INSIDE PIPE
ONE END
F
C.C. 1:5:10
CRACK IN CONCRETE
'A' CLASS HUME PIPE
3'-0"
3'-4"
6'-4"
CRACK INSIDE PIPE
CRACK INSIDE PIPE
OTHER END
G
TEST No. 3
1/4 DIA RODS @ 1' c/c BOTH WAYS
R.C.C. 1:2:4-3" AT TOP AND 7" ON SIDES
3'-0"
2'-8"
4'-6"
C.C. 1:5:10
H
WOODEN FRAME
1/4" DIA RODS AT 1' C/C
3'-0"
7"
3" R.C.C 1:2:4
3' DIA A CLASS HUME PIPE
3'-4"
G.L
SECTION OF WOODEN FRAME
8'-0"
3'-0"
PLAN OF WOODEN FRAME
I
3'-0"
CRACK ON TOP RIGHT THROUGH
R.C.C. 1:2:4 3"
CRACK ON TOP RIGHT THROUGH
CC 1:5:10
G
L
3'-0"
4'-6"
a, b, c ARE PLACES WERE LONGITUDINAL CRACKS DEVELOPED INSIDE THE PIPE RIGHT THROUGH

ANNEXURE 3.—Cost of typical Designs for barrels.

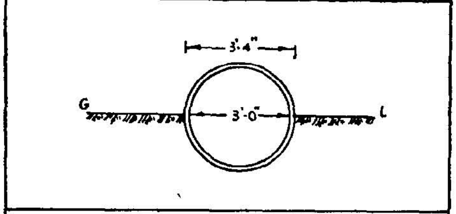
1 'A' Class Pipe without Concrete Bedding



	Rs.	A.
24 R. Ft. of pipes at Palghat at Rs. 15-1-0/R. Ft. ...	361	8
2 Collars at Palghat at Rs. 8-4-0 each ...	16	8
24 R. Ft. transporting to site, laying and jointing pipes and Collars at Rs. 3-8-0 per R. Ft. ...	84	0
Total ...	462	0
Cost of barrel per R. Ft. ...	19	3

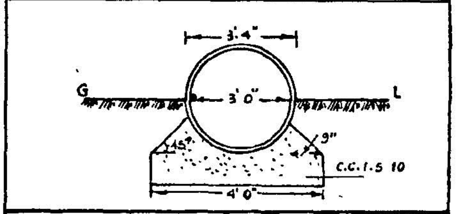
Note:—Fails with 5 ft. of sand embankment

2 'B' Class Pipe without Concrete Bedding



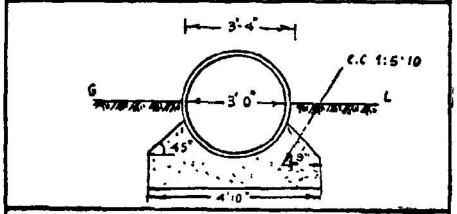
	Rs.	A.
24 R. Ft. of pipes at Palghat at Rs. 27-9-0/R. Ft. ...	661	8
2 Collars at Palghat at Rs. 12-4-0 each ...	24	8
24 R' Ft. transporting to site, laying and jointing pipes and collars at Rs. 3-8-0/R. Ft. ...	84	0
Total ...	770	0
Cost of barrel per R. Ft. ...	32	1

3 'A' Class Pipe with Concrete Bedding



	Rs.	A.
24 R. Ft of pipes at Palghat at Rs. 15-1-0/R. Ft. ...	361	8
2 Collars at Palghat at Rs. 8-4-0 each ...	16	8
24 R. Ft. transporting to site, laying and jointing pipes and collars at Rs. 3-8-0/R. Ft. ...	84	0
143 C.Ft. cement concrete 1:5:10 at Rs. 92-0-0/100 C.Ft.	132	0
Total ...	594	0
Cost of barrel per R. Ft ...	24	8

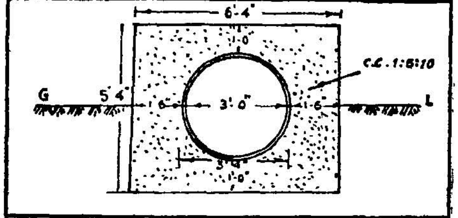
4 'B' Class Pipe with Concrete Bedding



	Rs.	A.
24 R. Ft. of pipes at Rs. 27-9-0/R. Ft. ...	661	8
2 Collars at Palghat at Rs. 12-4-0 each ...	24	8
24 R. Ft. transporting to site, laying and jointing pipes and collars at Rs. 3-8-0/R. Ft. ...	84	0
143 C Ft. cement concrete 1:5:10 at Rs. 92-0-0/100 C.Ft.	132	0
Total ...	902	0
Cost of barrel per R. Ft. ...	37	6

Note:—Safe for embankments within 6 feet.

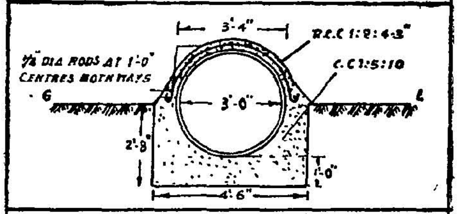
5 'A' Class Pipe with Concrete Encasement



	Rs.	A.
24 R Ft. of pipes at Palghat at Rs. 15-1-0/R Ft. ...	362	0
24 R. Ft. transporting to site, laying and jointing pipes at Rs. 2-8-0/R. Ft. ...	60	0
600 C.Ft. cement concrete 1:5:10 at Rs. 92-0-0/100 C.Ft. ..	552	0
Total ..	974	0
Cost of barrel per R. Ft. ..	40	6

Note:—Fails with 27·5 feet of embankment.

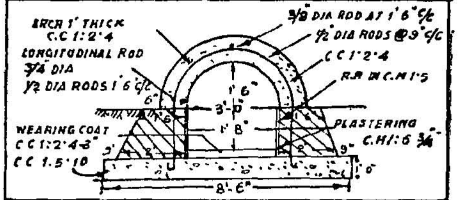
6 'A' Class Pipe with Concrete Bedding and R.C.C. Cover on Top



	Rs.	A.
24 R. Ft. of pipes at Palghat at Rs. 15-1-0/R.Ft. ...	362	0
24 R. Ft. transporting to site, laying and jointing pipes at Rs. 2-8-0/R. Ft. ...	60	0
183 C.Ft. cement concrete 1:5:10 at Rs. 92-0-0/100 C.Ft.	168	0
40 C. Ft, reinforced cement concrete at Rs 4-0-0/C. Ft.	160	0
Total ...	750	0
Cost of barrel per R. Ft. ...	31	3

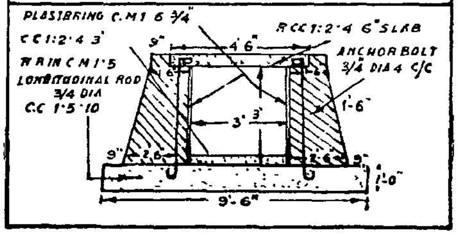
Note:—Fails with 17.7 feet of embankment

7 Barrel with Random Rubble side walls and Cement Concrete arch



	Rs.	A.
204 C.Ft. cement concrete 1:5:10 at Rs. 92-0-0/100C.Ft.	188	0
183 C.Ft. cement concrete 1:2:4 at Rs. 169-0-0/100C.Ft.	30	0
147 C. Ft. random rubble in C. M. 1:5 at Rs. 84-0-0 per 100 C. Ft. ...	123	0
161 C Ft. cement concrete 1:2:4 (Arch) at Rs. 2-12-0/C.Ft.	415	0
72 S.Ft. plastering in C.M. 1:6, ¾" thick at Rs. 12-8-0 per 100 S Ft. ...	9	0
Total ...	765	0
Cost of barrel per R Ft. ...	31	9

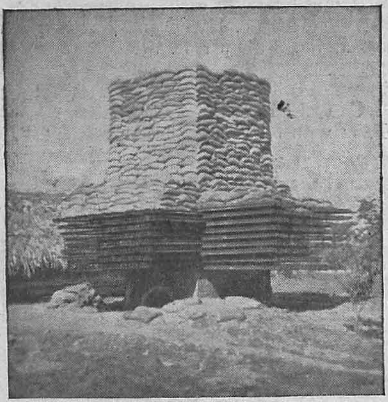
8 Barrel with Random Rubble side walls and Reinforced Cement Concrete Slab on Top



	Rs.	A.
228 C Ft. cement concrete 1:5:10 at Rs. 92-0-0/100C.Ft.	210	0
18 C.Ft. cement concrete 1:2:4 at Rs. 169-0-0/100 C. Ft.	30	0
306 C.Ft. random rubble in C M 1:5 at Rs. 84-0-0/100C Ft	257	0
132 S. Ft. plastering in C. M. 1:6, ¾" thick at Rs. 12-8-0 per 100 S Ft.	17	0
54 C.Ft. reinforced cement concrete 1:2:4 at Rs. 4-0-0/C.Ft.	216	0
12 Nos. anchor bolts at Rs. 2-0-0 each ...	24	0
Total ...	754	0
Cost of barrel per R. Ft. ...	31	4

Note:—Rates adopted in this statement are those obtained for a typical undertunnel in Malampuzha Canal Dn. They may be varied to suit local conditions. The cost per Rft. excludes cost of Excavation, Refilling Front and Rear Cisterns, Head Walls, etc. It includes cost of barrel only. (Sketches not to scale.)

LOAD TEST CONDUCTED ON " A " CLASS R. C. HUME PIPE 3'-0" Dr.
Encased in plain concrete 1:5:10, 1'-0" at bottom and top, 1'-6" on sides.



When loading is incomplete

When loading is completed

rigidity is given to the pipe, it will withstand higher loads. However, conditions will be different if the pipe is subjected to a uniform internal or external pressure as in fluid pressure and such type of failure will not occur.

(v) The " B " Class Hume Pipe is heavily reinforced and is more suitable for undertunnels without external reinforcement. But here the cost per running foot of tunnel will be too high.

(vi) The results of the 3 tests are tabulated in Annexure 3 for guidance. Comparative costs of some typical designs of barrels suitable under embankments are given in Annexure 3. The rates adopted are for those actually worked out for typical cases in the Malampuzha Canals Division and may vary slightly in other cases, according to the leads for materials, cost of labour etc. The costs per running foot do not include cost of front and rear cisterns, head walls etc., but only include cost of the barrel. It also excludes cost of excavation and refilling.

ANNEXURE 2.

The Indian Hume Pipe Co. Ltd.

CIRCULAR.

It is necessary that before laying a water supply, drainage, Hume Pipe Line, or fixing a Hume Pipe culvert, all necessary information regarding static pressure, pumping head, height of covering on the top of the pipes or height of embankment on pipe should be fully investigated. For our ordinary culvert type of pipes, the enclosed tables will be useful :—

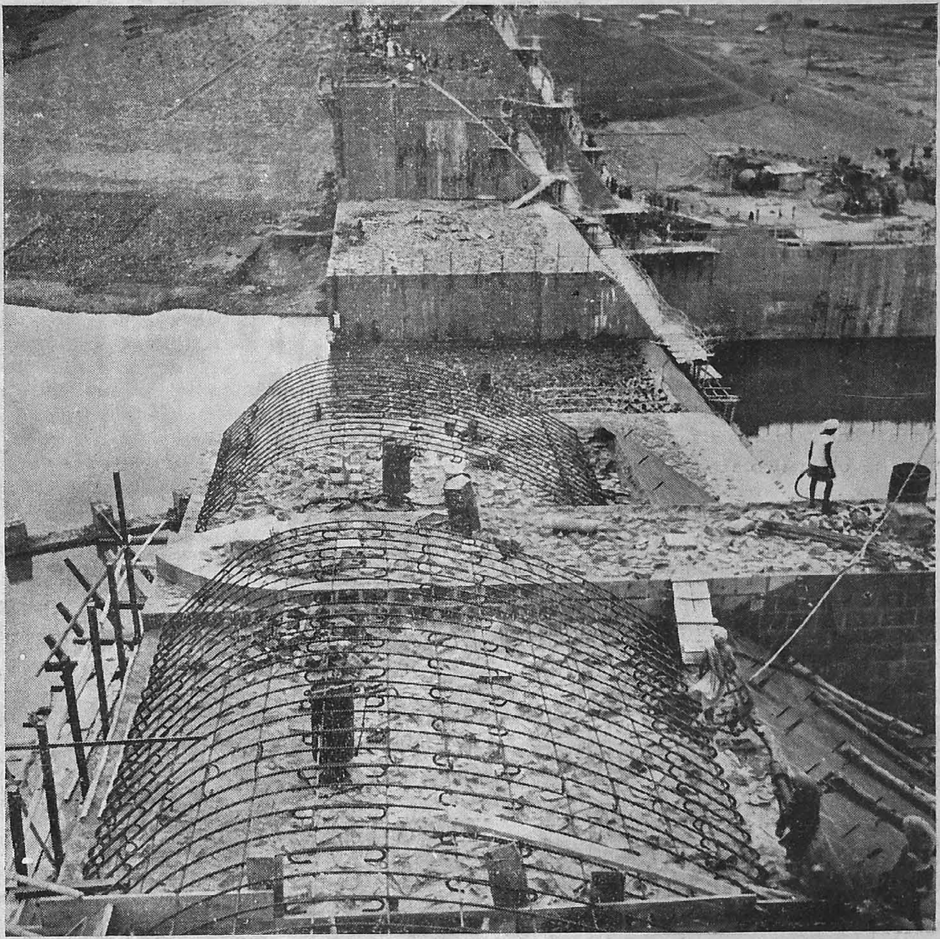
Permissible Depths for pipes in trenches under *1st Class Laying Conditions.*

Dia.	Ins.		Rft. Cover Clay filling 130 lbs. ft.
4"—6"—	9"	...	over 30
12"—	15"	...	14
	18"	...	13
	21"	...	11
	24"	...	10
	30"	...	9
	36"	...	8
	42"	...	7.5
	48"	...	7
	54"	...	6.5
	60"	...	6
	66"	...	5.5
	72"	...	5

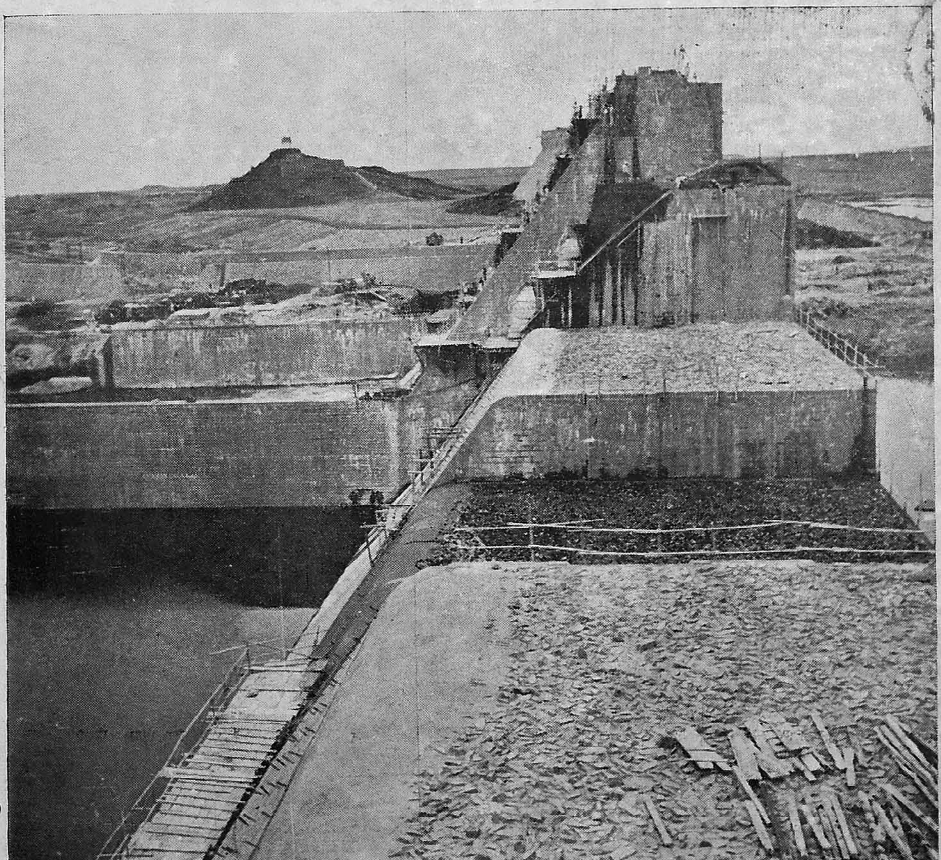
Permissible depths for Pipes under Embankments with first class bedding are as follows :

Internal Dia.		Hight of embankment on Top of pipe in feet.
4"	...	17
6"	...	12
9"	...	9
12"	...	7
15"	...	6
18"	...	6
21"	...	6
24"	...	6
30"	..	6
36"	...	6
42"	...	6
48"	...	6
54"	...	6
60"	...	5
66"	...	5
72"	...	5

Lower Bhavani Project, Coimbatore District, Madras State.

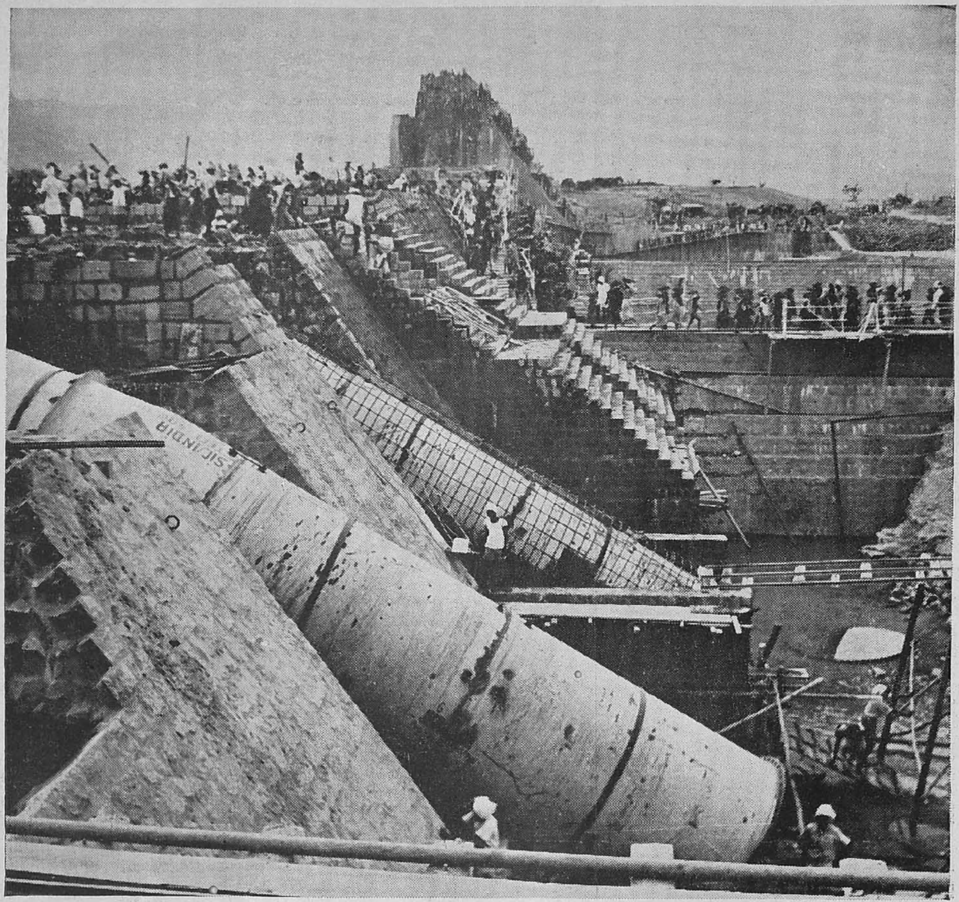


View showing the reinforcement in position in spillway crest. One of the piers is also seen



The Masonry with spillway portion left low to pass the South West Monsoon floods of 1952.

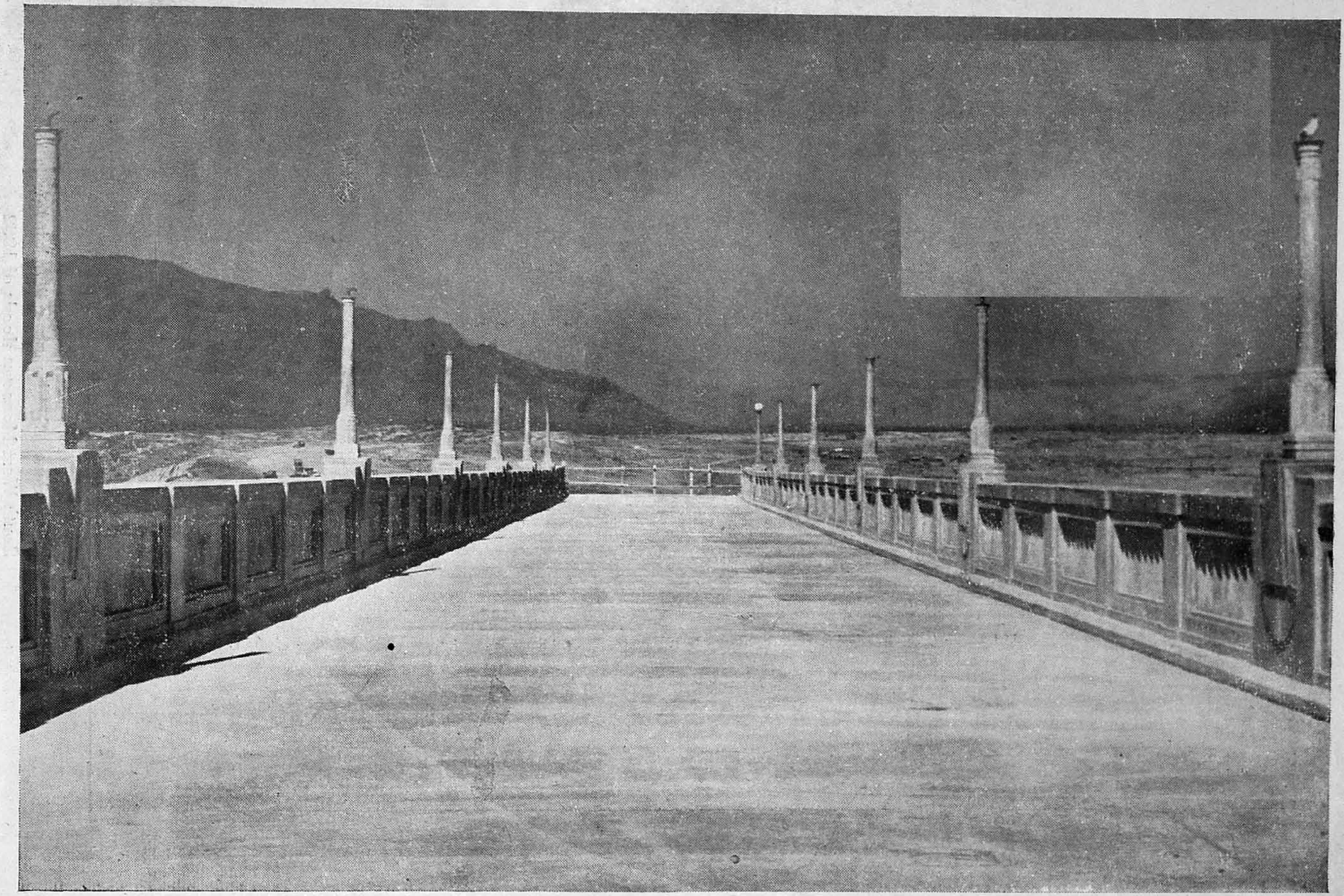
Lower Bhavani Project, Coimbatore District, Madras State.



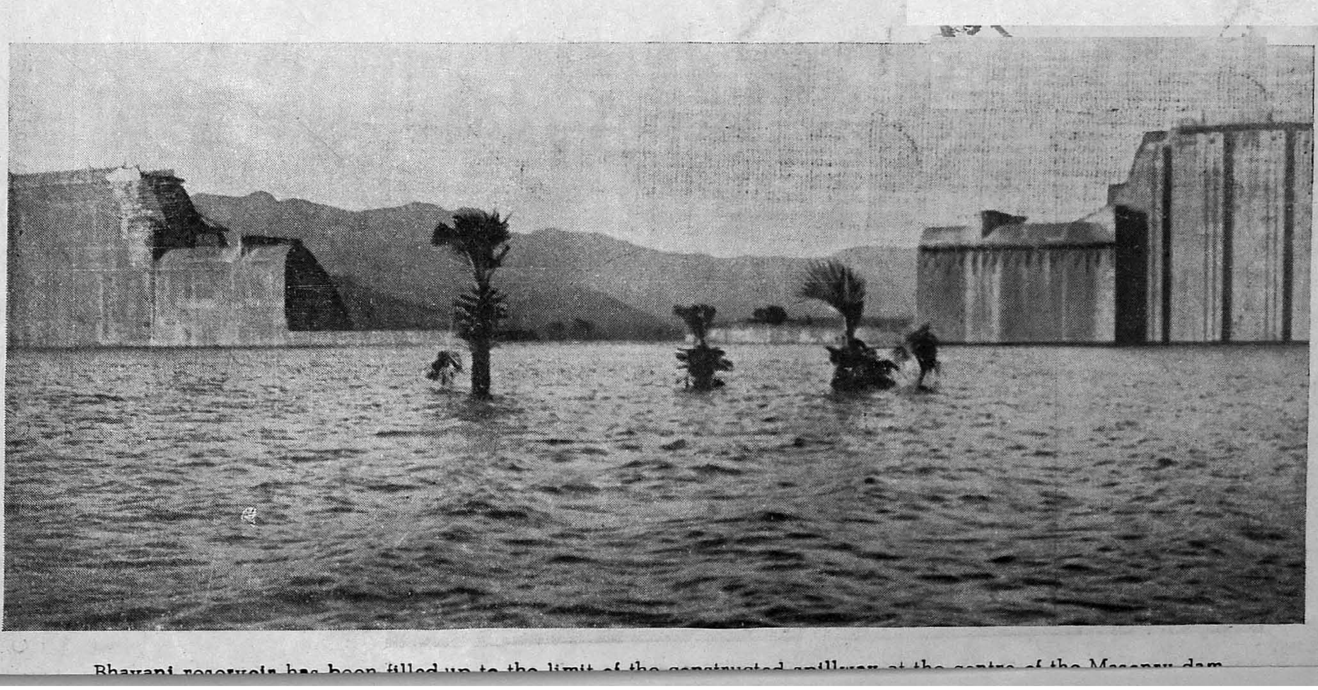
8'-0" dia. Penstock pipes erected in position. Two pipes have been concreted and the other two are about to be concreted

Earth dam in formation. Various earth moving machines at work. View from top of Masonry dam.

Lower Bhavani Project, Coimbatore District, Madras State.

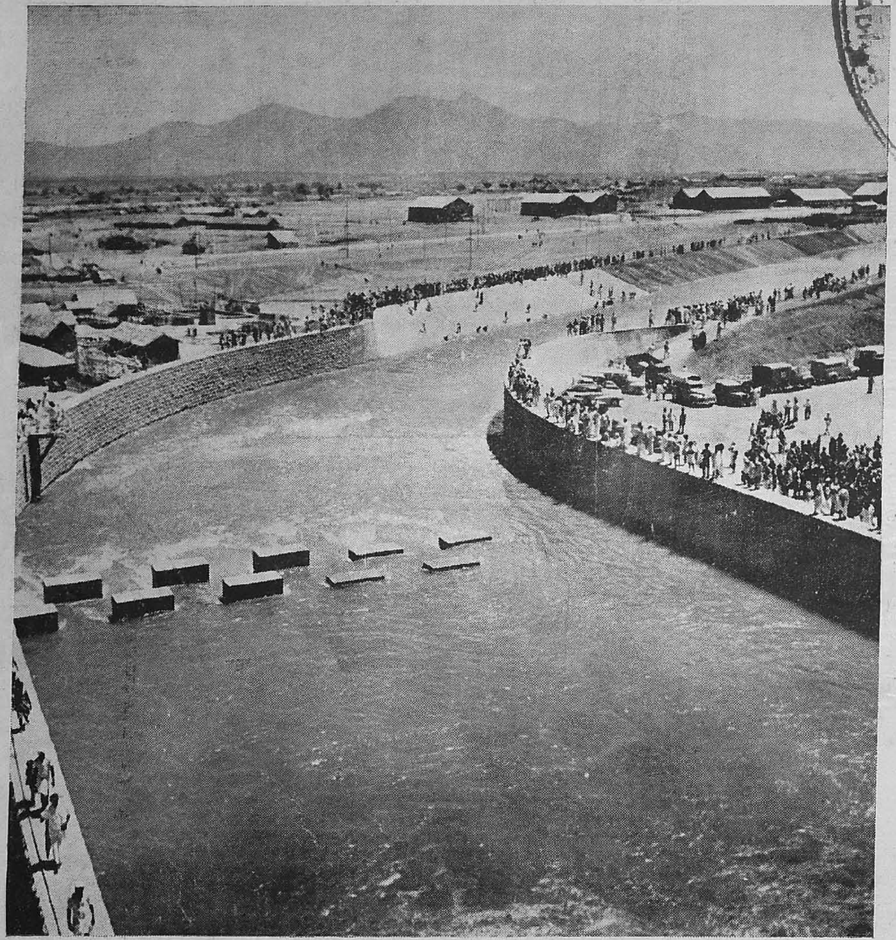


Finished Roadway with Parapet Walls and lamp-posts on top of dam

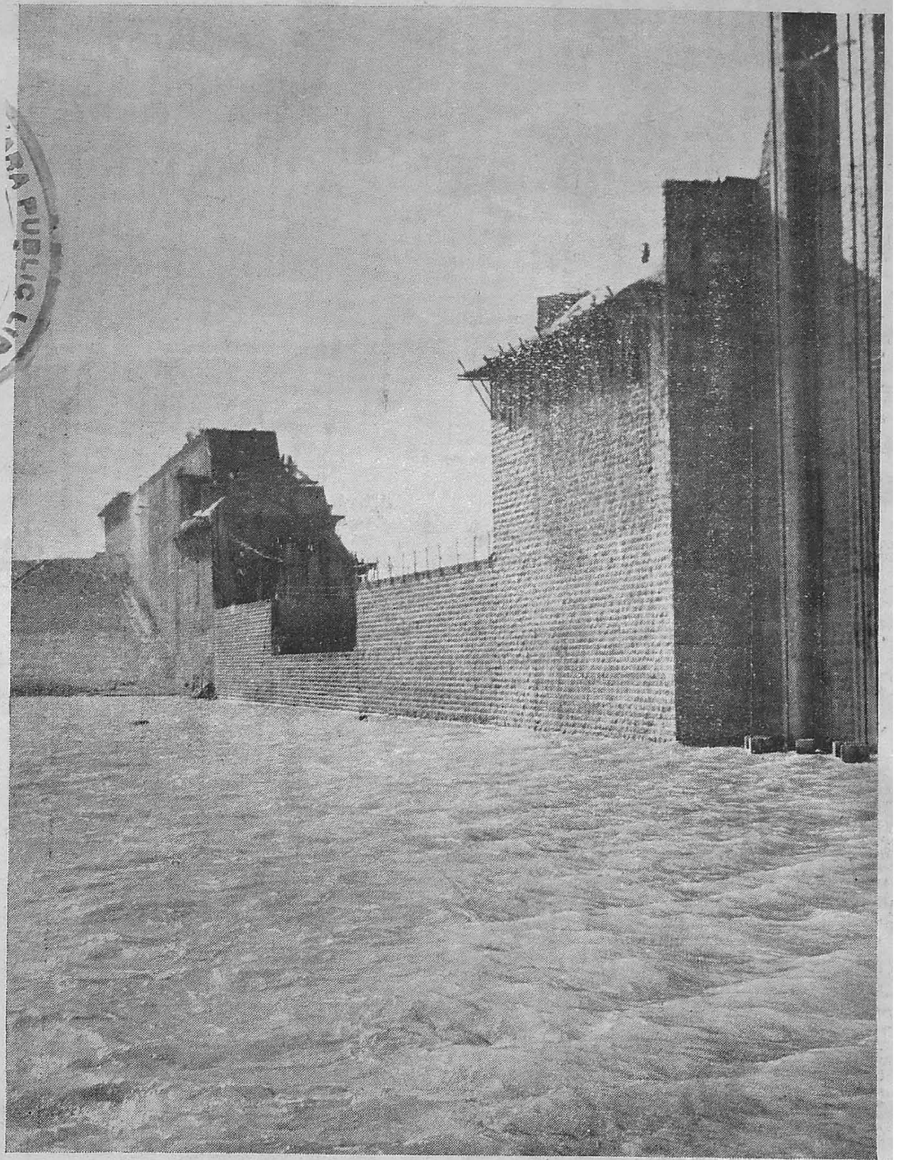


Bhavani reservoir has been filled up to the limit of the constructed spillway at the centre of the Masonry dam

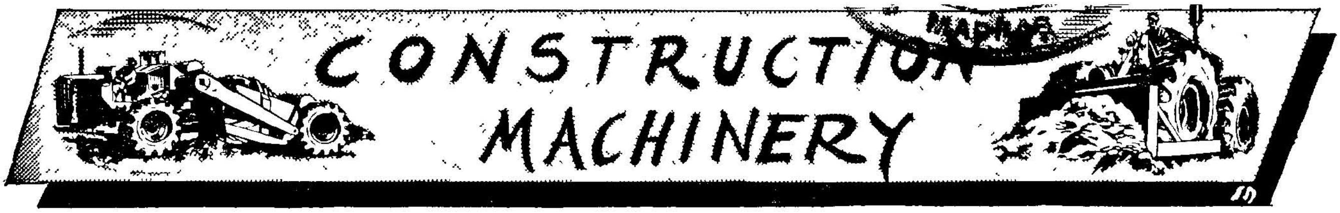
Lower Bhavani Project, Coimbatore District, Madras State.



Canal—The Masonry Guide Walls in rear of dam and the friction Blocks to concentrate the flow are seen in the picture



Front view of Masonry dam—Spillway portion left low is to take the South West Monsoon floods of 1952.



The Job to be Done

CONTENTS.

(1) Approach to the Subject ; (2) Steps in Scheduling ; (3) General Study ; (4) Study of the Job on Hand ; (5) Resources ; (6) Labour ; (7) Weather ; (8) Routes ; (9) Quantities ; (10) Work Estimate Sheet ; (11) Operations Time Schedule ; (12) Supervision ; (12) Inspections ; and (14) Responsibility.

1. Approach to the Subject.

The real reason for buying automotive or construction equipment is that there is a job to be done. The equipment will save labour, time and money.

The equipment is used out-of-doors. It must function in fair weather, rain, torrid heat and weather that reaches fifty below zero. These variations of extreme temperature are incorporated into the design of practically all automotive and construction equipment.

Hauling and construction operations change by the hour, the day, week and month The work load is much more likely to be changeable than constant

Owners of single pieces of equipment or managers of large operations must visualize the job to be done. It is different than opening a factory every morning where every machine is in its same place. On a given day the machine in the factory will run about the same speed, produce about the same number of items as on all other working days of the year, and require the same number of drops of oil in the oil cups The same operator usually runs the machine, sometimes for up to thirty years. In contrast to this, productivity of automotive and construction equipment is subject to orders for business, contracts, weather, variations in work to be done, time and a greater turn-over in machine operators than most other businesses.

Many jobs to be done are, therefore, different than the day before. Plans and decisions must be made immediately. The next job must be visualized instantly and clearly.

The first thing to do is to schedule. While the same procedure is followed in scheduling work on minor jobs, it is possible to continue these steps in handling larger jobs, but the basic considerations are used whether the job is large or small.

2. Steps in Scheduling

The steps in scheduling can be demonstrated by the use of a black board showing the four steps involved. We call it visualizing the job to be done. Every job should be clearly visualized in operation to completion before it is bid on, quoted on, or started. Visualizing can be taught as follows :

Scheduling of operations is done by the close study of the four steps. This is exactly the same as planning.

> BLACK BOARD
>
> 1. Visualize. Think out the job.
> 2. **Determine available resources.**
> 3. **Make a quantity survey.**
> 4. **Prepare a detailed schedule**
>
> Write and discuss each step separately.
> Do not erase.

Step No 1:—This includes the general factors affecting the project—distance, weight of material, size of boxes, routes, draw-bridges, over-head clearances, kinds of earth to move if construction work, loading and unloading facilities.

Step No. 2 :—This requires information as to what trucks, or buses, loading equipment, unloading equipment, loading platforms, unloading platforms, other equipment, or manpower is available.

Step No. 3:—The quantities of work to be done are shown on work order or contract. The order of sequence of operations or delivery time is usually given.

Step No. 4:—The schedule should show what work is to be done or what items are to be hauled on what day or days. If the job is over a period of weeks or months the schedule chart will have to be filled in daily. Later, this chart will show whether or not the job is on schedule. The value of the chart lies in the fact that steps can be taken in the early part of the job or contract to correct the phase of operations which is causing failure. When hauling or construction jobs are not completed on time, there is almost always a loss in profit.

The first four steps of scheduling should be clearly understood before Step number 5 is studied. Add to the black board Step No. 5, Estimates. A correct estimate of the cost of a job is arrived at by knowing Steps 1, 2, 3 and 4. The cost estimate must be correct before adding overhead, insurance and profit, when submitting a figure for doing a job.

3. General Study

When costs are so high as to prevent the getting of business, it is probably due to the fact that equipment production is not being reached. The entire investment is probably too large for the amount of work done (which means revenue.) More business is not necessarily the factor which will reduce cost. It may simply make losses greater. Therefore, with competition as it is today, trucks and construction equipment must produce to capacity in order to effect costs at least as low as the competitor. One of the hardest things to get across to drivers, mechanics and even foremen in the automotive transportation and construction business is that goods hauled or moved, be it bananas, oatmeal, pig-iron, dixie cups, ice cubes, lumber, gravel, or people, produces income; money for the company. This money is to pay wages and other expenses. There is no other money to be had—*the company hauls something and gets paid for it*. All effort by supervisors and employees must be toward one goal.. *To haul something, to get money for doing the job, to accomplish something.*

In some tightly-organized automotive transporation businesses the spirit of "get it hauled quick" is obvious—drivers will boast about their own company if they are proud of it. It is recommended that anyone planning to get on in the automotive transporation or construction business keep always in mind these factors. Haul it, move it, get it done—or the money will not be paid.

4. Study of the Job at Hand

It makes no difference if the job is large or small. The job on hand must be kept in mind. By this is meant that if there is only one truck, one bus, one bulldozer, or one road grader, the income is in relation thereto. Production must be watched diligently—expenses accumulate. With big jobs, having many trucks or productive machines, there is a tendency to say, "We'll give her the works tomorrow." NO. Tomorrow is too late. Every day's performance should be planned ahead (visualized) so that it pays its part of the project and contributes its part of the profit to the whole job. An operating profit is necessary at the end of each job. Out of this comes the money to pay taxes, overhead and depreciation. The job at hand is the important one—every working day. It must be kept in mind and studied, so that it rolls easy from the start.

5. Resources

In order to do a job expertly enough to provide a profit, it is necessary to consider resources. These include:

A. Equipment in operable and good condition.
B. Shops to maintain the equipment.
C. Man-power.
D. Money to pay employees.
E. If trucks are to be loaded or unloaded at a distant place then manpower or credit is needed there.
F. Credit is needed along the route for fuels and supplies. When visualizing a job to be done, resources to accomplish the job must be kept in mind.

6. Labour

Trucks and construction equipment must operate with a minimum of idling or waiting time. Therefore, when certain kinds of goods are hauled requiring manual labour in connection with loading or unloading, this must be kept in mind when visualizing the job to be done. The cost of a machine (driver, gasoline, oil and invest-

ment) for one hour of idleness is usually greater than the cost of expeditions loading and unloading. Many truck owners assume waiting time for loading and unloading as necessary. However, there are many successful transportation men who do not. Waiting can be observed at terminals and warehouses throughout the country —drivers wandering about, wondering who is going to unload their truck.

7. Weather

Abnormal weather conditions, continuous rain, severe storms or below freezing temperatures can seriously slow up hauling, productivity and progress. It can cause costly accidents. This is especially true of jackknifing by truck-trailers on the highways.

8 Routes

Knowledge of routes is necessary for city and long-distance hauling. In the city minutes can be saved up to important totals. Routes in cities should take into consideration railroad crossings, streets with a minimum of Stop and Go signs, draw-bridges and light load bridges. Work should be planned so that drivers will not have to call up the dispatcher and ask for a different route. The truck should load, proceed to destination, unload and return as quickly as possible. When a truck earns two hours' pay and the driver spends one-half hour looking for his destination, a profit is not achieved.

Up-to-date information about highways where long-distance hauling is involved is essential to making the trip pay and show a profit. All trips should make a profit. Sending a truck or a truck-trailer costing upward of ten thousand dollars across country without exacting route information is like sending a ship to sea without a compass. The pay-load is based on a competitive price. There will be a fixed amount of return. The truck expense and wages must not exceed a certain sum. The route must be direct, going and coming. Highways are sometimes closed off for miles due to repairs, new construction, spring thawing, and other unforeseen conditions, with only local announcement. Income for truck-hauling does not permit the extravagance of picking new routes for each trip.

9. Quantities

Quantities are taken from a job-sheet or conract. Quantities are also descriptive. They form a pictute as soon as known. This is why quantities should be listed clearly on the work-sheet whether the job is small or large.

On a small job quantities usually determine the size of truck to be used. In addition they reveal the type of truck. Freight to be hauled takes many forms. Examples are:

A.	Flour	.. Covered truck
B.	Machinery (farm)	.. Open truck
C.	Cement blocks	.. Flat-rack (heavy)
D.	Office furniture.	.. Light truck (covering)
E.	Sand	.. Dump truck

Quantities in a construction job identify types of equipment to be used. Examples are:

A.	Hard rock	.. Air compressors,
B.	Clay excavation	.. Bulldozers, scrapers, pushertractors
C.	Gravel	.. Dump trucks
D.	Culvert pipe (concrete)	.. Flat-rack (heavy)
E.	Lumber	.. Flat-rack or stake truck
F.	Diesel oil	.. Tank truck
G	Form trusses	.. Stake truck
H.	Concrete paving	.. Dump trucks
I.	Cement (sacks)	.. Dump trucks or flat bed
J.	Cement (bulk)	.. Chassis with cement tank
K.	Surfacing	.. Graders, rollers
•L.	Asphalt surfacing	.. Rollers
M.	Embankment or fill	.. Sheepsfoot rollers
N.	Piling	.. Pile driver
O	Trenches	.. Trench digger

10. Work Estimate Sheet

Some hauling businesses can be operated on a first come, first served basis. The operations are small or limited to one kind of goods to be hauled. It is intended to keep it small. It may be a fuel truck delivering oil to homes. The owner may be the driver.

Many businesses selling to the public leave delivery of their goods up to the trucking department, shipping clerk or warehouseman. The owner of the business does not know how many customers are disappointed by failure to deliver on schedule. If the owner does confront the trucking department, plausible alibis usually can be produced.

A work estimate sheet showing one or one hundred days of hauling will increase hauling production. The work estimate sheet eliminates to a considerable degree the costly operation of going back over a similar route with another little package, one sofa, one sack of cement, one crate of oranges, any one of which could have been on the truck the first trip. Perhaps the truck passed within three blocks of the place, three miles out. It may cost more to make the second

trip with a little package on a big truck than there is profit on the sale. On the first trip it would have been nil in delivery expense—there would have been a profit for the company.

A work estimate sheet can consist of a pocket-size reminder note-book or a set of standard-type drawing sheets showing estimates of work by months. The important thing is that when an expensive-to-operate machine is going some place, it should deliver or pick up freight in that area, on that trip.

Examples

A. When a pick-up truck is sent to a town or city thirty miles distant for repair parts it should get all the items thought of as needed (written down, a work estimate sheet) and not be sent on the same trip within hours of its return, for a forgotten item.

B. Dead-heading (going or coming empty) should be avoided when it is possible. Reminder notes (work estimate sheet) can eliminate some dead heading.

If all unnecessary trips, minutes or hours of operation in one year are totalled up it will be found that the cost of gasoline is a considerable item, to say nothing of wages. Loose-end expenses are not tolerable in many businesses and this includes automotive transportation.

For extensive hauling the work estimate sheet should include customer, item number, starting and finishing date, description of work (goods to be hauled or type of work), quantity type of equipment, number of pieces of equipment; hourly, daily or trip output per machine, total hours, days or trips, and man hours (driver, operator and labour).

Example.

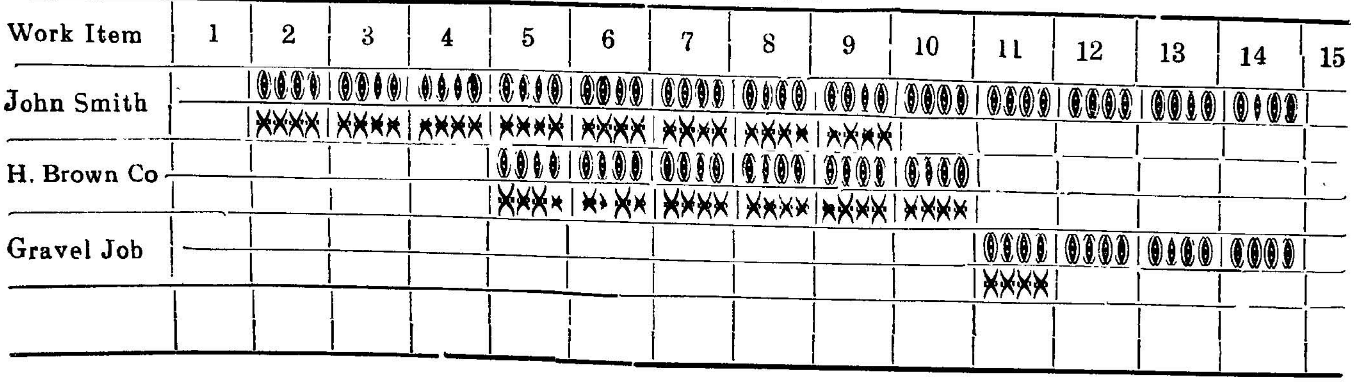
Customer or job Location.	Item No.	Start Date.	Finish Date.	Description of Work.	Quantity Tons Cases, lbs. cu. yds.	Type of Equipment.	No. Pcs. of Equipment.	Out put-Hour Daily trip.	Total Days Trips Hours	Man Hrs. Driver Operator Labour.
J. Smith	1	12/2	12/14	Water pipe	2,000 ton	Flatrack	4	100 D	12 D	384 Driver
H. B. Brown	2	12/5	12/10	Sand						
Gravel job	3	12/11	12/14	Gravel						

11. Operations Time Schedule

The operations time schedule chart will show progress of jobs on hand and also expected time of release of equipment.

One of several types of charts is as shown below:

Progress Chart for December



The Progress chart will show fuel and oil requirements in advance.

It is the blue-print for extensive hauling operations.

It can be used to show progress of all items on a construction job.

It serves as a reminder of things to be done and reduces the number of delays caused by forgetfulness.

In hauling and construction equipment operations, a tremendous number of details must function properly to make the project click. A small item can cause non-production of a big operation.

Examples

(*a*) A fleet of Diesel trucks hauling to a remote place. The unloading crane is out of fuel.

(*b*) A paving machine engine develops a cracked distributor cover. The entire operation shuts down.

12. Supervision

In practically all industrial operations a boss is looking over someone's shoulder. Most people work this way. Many do not like it, but management says it is mandatory. The machines are expensive, and even with employees of tried and proven skill, the foreman walks up and down the aisle, glancing here and there with trained eyes. Production, production—you can't get it unless you watch the employees.

It is not like this with the driver and the ten–thousand dollar vehicle. He not only goes out of sight of the foreman when he starts producing—he takes the the expensive machine with him, they are both out of sight. It takes good supervision and leadership to get production under circumstances like this.

Supervisors of automative transporation must be trained in qualities of leadership. Leaders can get results through respect and loyalty. A good leader should have the following qualifications.

1. Be a gentleman.
2. Know his business.
3. Be capable of understanding his employees' side of a problem. He should be able to feel the grievance—see it from the other's viewpoint.
4. Be honest to his superiors—and this should never be questioned. To the employee it should be unthinkable to be dishonest.

The supervisor should not act in such a manner that the driver detests the day's work and is glad to get out of sight.

The supervisor should ride with drivers occasionally and observe the job to be done. In this way he ties in the entire picture—observes and corrects loose ends that cause delays (non-production).

In the repair shop and on construction jobs this is not such a serious problem. The supervisor is close to the employees.

13. Inspections

Inspection is an integral part of good management. No one should expect a business to run itself or that facilities will stay clean (house-keeping). Inspection produces first-hand information, facts and knowledge of how the business is being operated.

Automotive transportation is a spread-out business. It cannot be seen from a supervisor's window. The shop, the dispatcher's office and the vehicles at distant points during production hours must be inspected.

14. Responsibility

Responsibility for good or bad automotive operations lies with the managers. Vehicles of today are precision-like in adequacy. Drivers are becoming more conscious of their importance to the industry and many fine roadways exist. The conditions are quite ideal compared to twenty years ago.

The manager is responsible. He must keep up with developments, increase his technical knowledge and step up his own organization. He must learn costs, keep production figures and continuously strive for more efficiency.

The manager must provide for training of those under him and be ready to adop modern concepts of efficient practices. Selection of personnel is one of his most important duties—he is responsible for their mistakes. The manager and his employees must work together to think out and accomplish the job to be done.

—"*Automotive and Construction Equipment,*" By C. W. Lindgren.

Progress of Research Work in Madras.

[*Note*:—The three Research Stations functioning under the control of the Chief Engineer for Irrigation, Madras P. W. D., are

(1) The Irrigation Research Station, Poondi,
(2) The Soil Research Station, Chepauk ; and
(3) The Concrete Laboratory, Chepauk.

These are of recent origin and have been doing very valuable and useful work on the research side ever since their inception. To enable the officers of the Department distributed throughout the State, know about these Research Stations and their activities, short resumes of these stations will be given in a series of articles. The first article commences with this issue.]

A. IRRIGATION RESEARCH STATION, POONDI, MADRAS.

(1944—1952).

" Take interest, I implore you in those sacred dwellings which one designates by the expressive term, Laboratories. Demand that they be multiplied ....that they be adorned. These are the temples of the future..............temples of well-being and of happiness. There it is that humanity grows greater, stronger, better ".

—Pasteur.

1. **Introduction**:—The Irrigation Research Station, Poondi, forms an important arm of the Public Works Department, Madras, and functions under the administrative control and technical direction of Sri L. Venkatakrishna Ayyar, B.A., B.E., I.S.E., Chief Engineer for Irrigation. Although the Station was created in the year 1944, and during the period of eight years of its service, sufficient useful work has been carried out to more than justify its existence, it has not been unusual, to receive from the distinguished visitors to the Station such questions as

(i) Why does the Public Works Department which is not a Research Organisation need this Station ?

(ii) When such outstanding Engineering Works as the Grand Anicut and Mettur Dam were built in this State without a Research Station, why is it now required ?

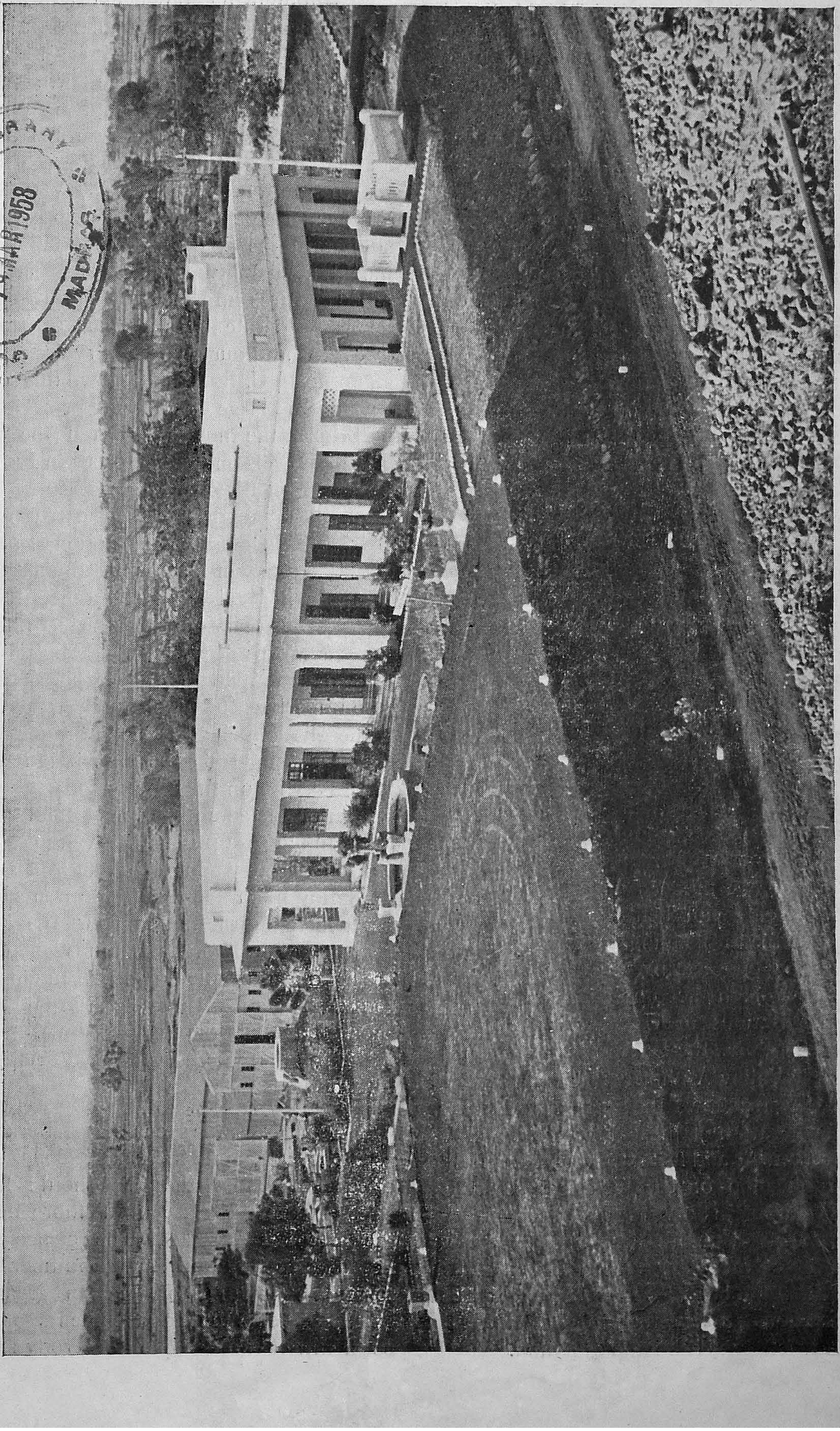
(iii) Why not make use of technical information given in text-books and Research Reports of Foreign Countries who maintain expensive laboratories instead of having this Station ?

(iv) Is the Station necessary, once the projects taken for execution in this State are completed ? . etc.,

These questions are indeed logical and in bringing out this brochure, attempt is made to furnish satisfactory answers for the same. The benefits accruing from the work of the Station are explained in detail and a brief description is given of the set up of the Research Station, nature of studies conducted and the outstanding achievements made so for. The article is well illustrated with photographs not only to make the perusal interesting but also to serve as documentary evidence of the record of its work.

Necessity for the Irrigation Research Station:—Our country, and especially the Madras State has a fine heritage of Engineering accomplishment. The Grand Anicut constructed 600 years ago, the Godavari and Kristna anicuts built a century back; and the Mettur Dam during 1925-1934 are monumental examples of contributions to Engineering skill. The Engineers who designed and excuted these works depended solely upon their long experience, the old established tools and devices of engineering, and not to a small extent, upon their intuitional perception. They had neither libraries to consult technical literature, nor laboratories to experiment. Their knowledge was limited enough, that they could commit to memory what all was needed in their designs and they employed such simple devices as a ball of mortar rolled in hand, the resistance to penetration of a walking stick in an earth bund under formation, the time taken for a float

PUBLIC WORKS DEPARTMENT



Irrigation Research Station, Poondi, Madras

thrown into water to traverse a certain distance etc. But the demands of a progressive civilisation, and along with it, human knowledge have now become so extensive, that the age-old practices are found no longer adequate for investigating, designing, constructing and operating Engineering works efficiently and economically. Advancement of science has furnished us so many technical aids, that the modern engineer, of necessity, will have to avail himself of these, "In utilising the Powers of nature to the best advantage of man," and in furthering him in the pursuit of happiness. Research is the key-note of scientific approach to any problem, and experimentation is the key-note of Research. Hence in a board sense it may be stated, that the terms Research and experimentation are synonymous.

The realisation of these facts had led the advanced countries like U. S A. to maintain extensive laboratories as adjuncts to their Engineering departments. These laboratories utilise the entire list of technical sciences such as physics, chemistry, geology, Hydraulics, Soil Mechanics, Photoelasticity, petrography, microscopy etc. But for the installation of these laboratories, such major undertakings as the 726 feet high Boulder dam could not have been under taken for the reason, that the answers for many unusual problems involved in the design and construction of such structures could not be found in text-books or personal files of experienced engineers. In modern engineering practice, the laboratories with their scientific tools are quite indispensable in planning, designing, building and operating engineering works at the least cost. A review of the accomplishments of the foremost organisations in U. S. A. akin to the P. W. D. Madras, *viz.*, the Bureau of Reclamation, Tennessey Valley Authority in U.S.A., Army Corps of Engineers, shows that the installation, staffing and operation of these laboratories had cost the Government and its tax payers absolutely nothing. Application of the technical sciences to engineering problems by means of laboratory facilities have saved many times their cost of existence in direct monetary values, and in addition had resulted in better, longer lasting works and contributions to engineering knowledge, which had attracted international attention.

Although the knowledge acquired by these various organisations is available in the form of technical memoranda, and it would be no doubt useful for reference in design, entire dependence on foreign publications cannot be placed to the extent of dispensing with separate laboratories of its own for the P. W. D. for the reasons that (i) Engineering problems are so varied in nature, that generally speaking, no two structures are similar in the matter of foundation condition, height, availability of materials at site, constructional features, and hence each individual problem needs a separate investigation; (ii) the resources of U.S.A. and our own country are different. For example, in U. S. A. no one would consider embarking on a large engineering project without the bull-dozer, the motor truck and the big cranes, power showels and cableways. In India, we have potential man-power, and it has to be utilised profitably by modifying the constructional practices, introducing machanisation to the extent considered advantageous (iii) the nature of problems tackled also are different. For example one of the primary duties of the large organisation of Army Corps of Engineers, U.S.A. is the Flood Control of the River Mississippi. This problem is so important for them that they built a model of the Mississippi river, about 1 mile long at an expense of about 6 (six) million dollars. In the Madras State on the other hand, the rivers flow within protected embankments, and flood control is not much of a problem. As another example, our canals carry a lot of silt, and their design for rendering them non-silting and non-scouring has been engaging the mind of our Irrigation Engineers. But in U.S.A. since most of their canals are lined, this problem is not of much importance to them. Hence it may be seen that the P.W.D. should have laboratories of its own, and published literature could be used, only to supplement its own findings.

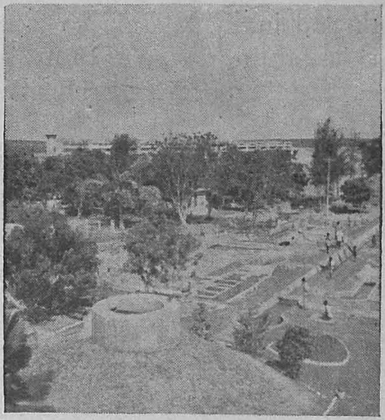
Apart from the fact, that laboratories such as Structural, Soil Mechanics, Concrete etc, are of equal necessity, the fact should however be stressed, that they are all the more necessary in the case of Hydraulics. The science of Hydraulics is essentially built up of a number of empirical formulae, though its origin is of great antiquity. In recent years the advancements of the science of aviation and applied aerodynamics have

enriched the field of Fluid Mechanics in general, of which Hydraulics forms a branch. However, Hydraulics cannot yet be classified as an exact science. Galelio, the famous philosopher, seemed to have remarked, "I have met with fewer difficulties in observations relating to the movements of heavenly bodies, notwithstanding their stupendous distances away, than in investigating the movements of flowing water which takes place before our very eyes." The laws governing many of the hydraulic phenomena are still imperfectly understood, and the analytical difficulties to be overcome before all the influencing factors can be evaluated, are very great. In such cases, experience based on the results of experiments, forms the only safe guide. Modern hydraulic science is thus based almost entirely upon experiment. In the design of hydraulic structures, the experimental tool that is employed is the small scale hydraulic model.

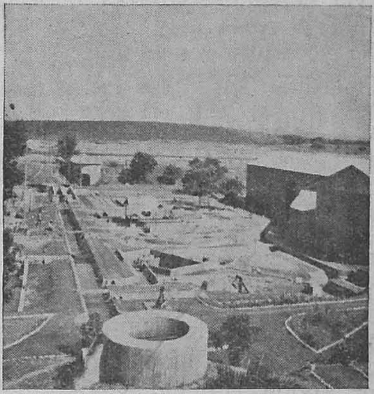
The realisation of the facts enumerated above, and the stimulus given by war to the large number of works under the Grow More Food Campaign, and Irrigation Project in the State led to the creation of Irrigation Research Station, Poondi in G. O. No. 440 M dated 14th February 1944 of the Government of Madras, during the time of Sri N. Govindaraja Ayyangar, B.A., B E., I.S.E., the then Chief Engineer for Irrigation. He was succeeded by Sri A. R. Venkatachari, B.E., M.I.E., M. ASCE, I.S.E., Chief Engineer, General and Irrigation who directed the work of the Station during the past six years. He has been in turn succeeded by Sri L. Venkatakrishna Iyer, B.A., B.E., I.S.E., Chief Engineer for Irrigation in the administrative control and technical direction of the Station. In the Research Station, while most of the work relates to investigations on small scale hydraulic models, studies relating to the evolution of cheap housing materials are also carried out. In fact the nature of studies conducted in the station may be described under

(i) Projects.
(ii) Maintenance works.
(iii) Basic Research and
(iv) Materials Tests.

Illustrative examples are furnished subsequently under various classifications above, but the following essential facts may require special mention.



Layout of Field Models—Regulator in back ground.



Layout of Field Models—M. B. shed in rear.

Investigations were carried out on problems relating to Projects both under investigation and those under execution such as the Ramapadasagar, Kistna-Pennar, Thungabhadra, Lower Bhavani, Malampuzha, Upper-Pennar, Pennar-Kumudavathi and a number of works under the Grow More Food Schemes.

Secondly solutions were furnished for problems of maintenance of existing Irrigation structures, such as scour protection below the anicuts of the Godavari, exclusion of silt from the Grand Anicut Canal in the Cauvery Mettur system, increasing the discharge through the Seethanagaram Head Sluice of the Kistna-Delta etc. Hence it may be seen that even if the work on the projects under execution were completed and no major projects would be undertaken in the near future, the Research Station should still continue as an essential unit of the P. W. D.

Research Work of a fundamental nature is also conducted in the Station so as to evolve working rules for the design of future structures without recourse to model experiments afresh in each case.

Another line of activity of the Station is the work on materials research which is carried out with the object of evolving economical substitutes for the conventional materials, such as bricks and steel, which, besides being expensive are sometimes not easily procurable and hence the adoption of the substitute materials not only reduces the cost of construction but also helps to speed up execution.

The progress of work of the Station is published in the form of an Annual Report. The Station is a participating member of the Research Committee, and other meetings organised by the Central Board of Irrigation and Power, to coordinate research work being carried out in various states in the country. It also took part in various exhibitions arranged in the Madras State, and also in the International Engineering Exhibition opened in New Delhi in January '51. Technical articles are contributed from the station to various professional journals, such as the (i) Central Board of Irrigation, (ii) Institution of Engineers (India), (iii) New Irrigation Era of the Madras Public Works Department, (iv) International Congress on Large Dams etc. The Station is visited by the students of engineering and technology colleges in the Madras State as a part of their study tours. Several distinguished visitors including statesmen, consulting engineers of international reputation, Research Directors of various stations in the country, etc, paid visits to the Station and recorded their appreciation of useful and valuable work being carried out here.

3. Set up of the Station.

The Research Station functions under the administrative control and technical direction of the Chief Engineer for Irrigation, Sri L. Venkatakrishna Ayyar, B.A., B.E., I.S.E. However, the work of the station relating to building materials is under the direction of Sri T. S. Venkatarama Ayyar, B.A., B.E., M.I.E., I.S.E., Chief Engineer for Buildings and General, and the work relating to Thungabhadra Project and Public Health has been under the direction of Sri M. S. Thirumale Ayyangar, B.E. (Mech) (Hons), M.I.E. (Ind), I.S.E., Chief Engineer for Thungabhadra Project and Public Health who has been recently succeeded by Sri N. Padmanabha Ayyar, B.A., B.E., M.I.E, I.S.E.

The Station is under the charge of the Research Executive Engineer. In this connection, it may be mentioned that Sri T. B. Kuttiammu, B.E., A.M.I.E., was the first Executive Engineer to be in charge of the station, since its commencement in 1944 for a period of 5 years. He was succeeded by Sri J. I. Coilpillai, B.E., A.M.I.E., who held charge of the station for about 2 years and 8 months, till the end of March 1952. He has been succeeded by Sri J. Visweswara Rao, B.E., M.SC, A.M.I. STRUCT. E. (Lond), Assoc. M.ASCE., A.M.I.E., who was promoted from the post of Assistant Research Officer and appointed as Research Executive Engineer.

The Station is located at Poondi, 37 miles from Madras and 7 miles from Trivellore, where a Reservoir, by name Satyamurthi Sagar had been constructed for augmenting the water supply to Madras. Availability of reservoir water for running the hydraulic models, and nearness of Poondi to Madras enabling frequent inspections of the work by the Chief Engineer for Irrigation, were the considerations in locating the station at Poondi.

The Station consists of a main laboratory building 40 feet wide x 80 feet long with 8 feet wide verandah on three sides, two M.B. sheds 106 x 38 feet wide and also open air space for setting up the models. The water supply to the models is drawn from the Reservoir through a sluice constructed in the right flank bund of the Poondi Regulator with sill at + 125, the F.R.L. of the Reservoir being + 138. The models could be fed by gravitational flow of water when the reservoir level is above + 125 and if it falls below this level, there are arrangements for pumping up from the cistern on the rear side of the regulator. The water leaving the models, enters the river again on the downstream. If however, during abnormal periods of drought, there is no water even for pumping from the cistern, to meet this situation, the station has been recently equipped with a circulating system of water supply wherein water is drawn to models from the static tanks, and the return water from the models, will be pumped back to the tanks.

The station is furnished with Electric supply. The equipments of the station consist of several glass-sided and masonry flumes, and river model trays. There are precision instruments for reading the water levels, velocities and discharges. There is an excellent workshop where the models and other appurtenances could be manufactured. Sufficient stocks are held of a variety of materials such as tubings of glass, rubber and copper, colouring dyes, plastic sheets, as well as hard-ware materials. A separate building is provided for the office of the Research Executive Engineer.

With the expansion of the Research Station the available space on the right flank of the Poondi Regulator has been used up. Consequently a large plot of ground suitable for river models, on the left flank of the regulator, was taken up to provide space for further expansion A sluice to feed these models, and a Field Research Laboratory building have already been constructed, and further development has been planned.

The staff of the Station are provided with residential quarters, in a colony with well laid out roads and gardens close to the Research Station. There is a Government dispensary and a protected water supply for the colony. The station is connected by bus service with Madras. There is a provision Stores and a Club for recreational facilities.

RIVERS IN MADRAS.

(*Continued from page 22*)

Ellis Choultry. This anicut is 2,000 ft. long made up of (1) scouring vents for a length of 90′-9″ (2) falling shutters for 696 feet, (396 feet on the left and 300 feet on the right) and solid masonry crest for the balance length of 1,213 feet 3 inches. The height of falling shutters is two feet. The anicut is founded on well foundation and the height of anicut from top of well will be 8 5 ft. and height above bed level will be 3.5 feet. This besides giving assured supply to the existing first crop of 13,000 acres, has brought 870 acres of new area also into cultivation and facilitates raising a second crop over an area of 2,340 acres.

In addition to the above, 19 open head channels take off from the river above Tirukkoilur anicut and 47 below this anicut. The total registered ayacut under these 66 channels is 41,856 acres.

Proposals to form two reservoirs across this river, one near Krishnagiri in Salem District and the other near Sathanur in North Arcot District are under consideration.

South Pennar.

The South Pennar, also known as Ponniyar River, rises on the South-Eastern slopes of Chennakesava hill, North-West of Nandidrug in Mysore State. In the Mysore State this river is known as Dakshina (South) Pinakini. After traversing 53 miles in the Mysore State, it enters the Madras State, three miles North-West of Bagalur village of Hosur Taluk, Salem District. The total length of the river from its source to the sea is 360 miles.

Chinnar, Chinna Ar, Markhanda Nadhi (made of the two branches, the Markanda Nadi and the Nachchikuppam Ar) Pullampatti Ar, Pambar, Vanniar, Kovil Ar, Pamban Ar, Musukunda Nadi and Turinjalar are the chief tributaries of the river.

In its long stretch from its source to the sea, the fall in the several sections of the river is very varied, reaching in some places such steep grades as 17 ft per mile and 10 ft. per mile, while at the lower reaches in the South Arcot District the fall is far less. There are several rapids in the river in the upper reaches with drops varying from 4′ to 25′.

The drainage area of 5,073 sq. miles of the river lies under the influence of both South West and North-East monsoons. But the portions of the river above Nedungal Anicut of the Salem District generally get more drainage during the South-West monsoon than the North-East monsoon, while below the Nedungal Anicut, it is the reverse, the principal freshes occurring during the North-East monsoon. The river will be at high floods in the months of May, June, July and August, but the periods of high floods are of short duration only.

The major portion of the river passes through wooded country, through deep ravines and narrow gorges, with the country at the sides rising steeply to heights of about 300 ft. above the bed of the river. There is no flow in the river except during monsoonic seasons when too, it comes in flash flows of short duration immediately after which the flow dwindles down to a trickle of few cusces.

There are no dams or reservoirs across the main river. The only dam across its tributaries is the Markhandiya Reservoir across the Markhandiya Nadhi near Budikote in Mysore State. The dam was completed in the year 1942 and is 1,000 ft. long. This is made up of two continuous lengths of 700 ft. of non-over flow section 80 ft. high on the left and 300 ft. of over flow section on the right, having a height of 75 ft. The channel taking off from the left end of this dam feeds the Boothakode tank in the Mysore State and commands an ayacut of about 1,000 acres.

There are four anicuts across the main river in the Madras State *viz.*, (1) Aliyalam Anicut, (2) Nedungal Anicut, (3) Tirukkoilur Anicut and (4) Ellis Choultry Anicut.

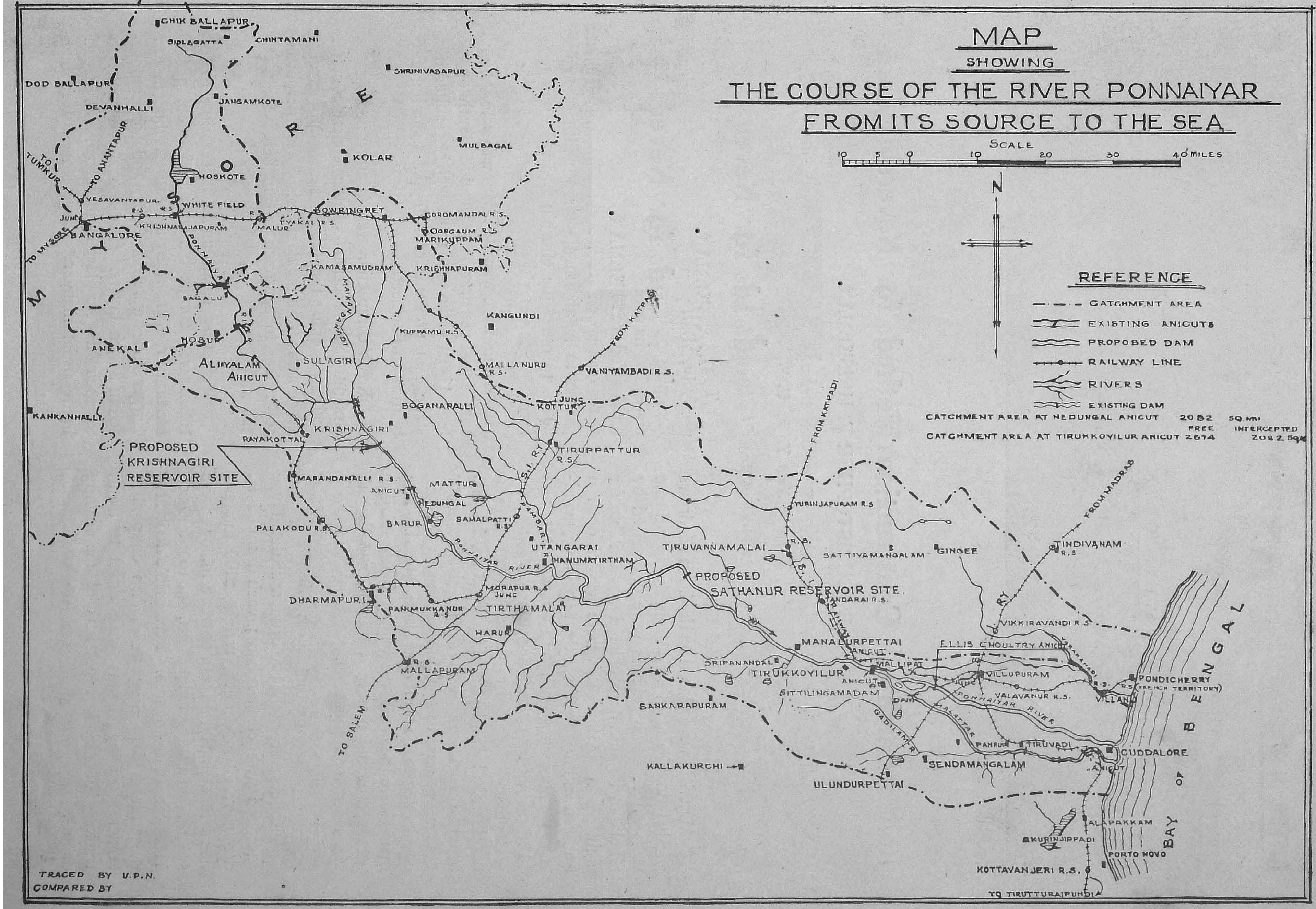
The Aliyalam Anicut is situated in the Hosur Taluq of Salem District and serves an area of 218 acres.

The Nedungal Anicut in Krishnagiri Taluq of Salem District has an ayacut of 4,500 acres.

The Tirukkoilur Anicut is situated 18 miles below the entry of the river into the South Arcot District and is about 4½ miles east of Tirukkoilur town. At this anicut, the river is nearly 2¼ furlongs wide and its bed is sandy. The anicut is nearly 1,589 ft. in length and 3 ft. in height. It feeds a number of tanks in Tirukkoilur and Villupuram taluqs and has an ayacut of 28,000 acres. Below the Tirukkoilur anicut the river splits into two branches the Ponniar and Mallatar before finally emptying into Bay of Bengal, north of Cuddalore town.

The Ellis Choultry anicut has been constructed recently (1950) and is situated 2 miles above the old Alangal Channel Head sluice near the

(Continued on page 21)


MAP
SHOWING
THE COURSE OF THE RIVER PONNAIYAR
FROM ITS SOURCE TO THE SEA
SCALE
10 5 0 10 20 30 40 MILES
N
REFERENCE
CATCHMENT AREA
EXISTING ANICUTS
PROPOSED DAM
RAILWAY LINE
RIVERS
EXISTING DAM
CATCHMENT AREA AT NEDUNGAL ANICUT 2082 SQ.MI.
FREE INTERCEPTED
CATCHMENT AREA AT TIRUKKOYILUR ANICUT 2674 2082 SQ.M
MYSORE
CHIK BALLAPUR
SIDLAGATTA
CHINTAMANI
SHRINIVASAPUR
DOD BALLAPUR
DEVANHALLI
JANGAMKOTE
MULBAGAL
KOLAR
TO TUMKUR
TO ANANTAPUR
HOSKOTE
YESAVANTAPUR
WHITE FIELD
BOWRINGPET
COROMANDAL R.S.
BANGALORE
KRISHNARAJAPURAM
MALUR
TYAKAL R.S.
OORGAUM R.S.
MARIKUPPAM
TO MYSORE
KAMASAMUDRAM
KRISHNAPURAM
BAGALU
KANGUNDI
KUPPAM R.S.
FROM KATPADI
HOSUR
ANEKAL
MALLANURU R.S.
VANIYAMBADI R.S.
ALIYALAM ANICUT
SULAGIRI
PONNAIYAR
MARKANDA NADI
KOTTUR
JUNC
BOGANAPALLI
KANKANHALLI
KRISHNAGIRI
RAYAKOTTAI
TIRUPPATTUR R.S.
FROM KATPADI
PROPOSED KRISHNAGIRI RESERVOIR SITE
MARANDAHALLI R.S.
MATTUR
ANICUT
NEDUNGAL
SAMALPATTI R.S.
TURINJAPURAM R.S.
FROM MADRAS
PALAKODU R.S.
BARUR
PAMBAR
UTANGARAI
HANUMATIRTHAM
TIRUVANNAMALAI R.S.
SATTIYAMANGALAM
GINGEE
TINDIVANAM R.S.
PONNAIYAR RIVER
PROPOSED SATHANUR RESERVOIR SITE
TANDARAI R.S.
DHARMAPURI
MORAPUR R.S. JUNC
PANMUKKANUR R.S.
TIRTHAMALAI
HARUR
VIKKIRAVANDI R.S.
BAY OF BENGAL
MANALURPETTAI
ANICUT
ELLIS CHOULTRY ANICUT
MALLAPURAM R.S.
SRIPANANDAL
TIRUKKOYILUR
ANICUT
MALLIPAT
VILLUPURAM
JUNC
PONDICHERRY R.S. (FRENCH TERRITORY)
VALAVANUR R.S.
SITTILINGAMADAM
DAM
VILLANUR
SANKARAPURAM
PONNAIYAR RIVER
MALATTAR
GADILAM R.
TO SALEM
PANRUTI
TIRUVADI
CUDDALORE
ANICUT
KALLAKURCHI
SENDAMANGALAM
ULUNDURPETTAI
ALAPAKKAM
KURINJIPPADI
PORTO NOVO
KOTTAVANJERI R.S.
TO TIRUTTURAIPUNDI
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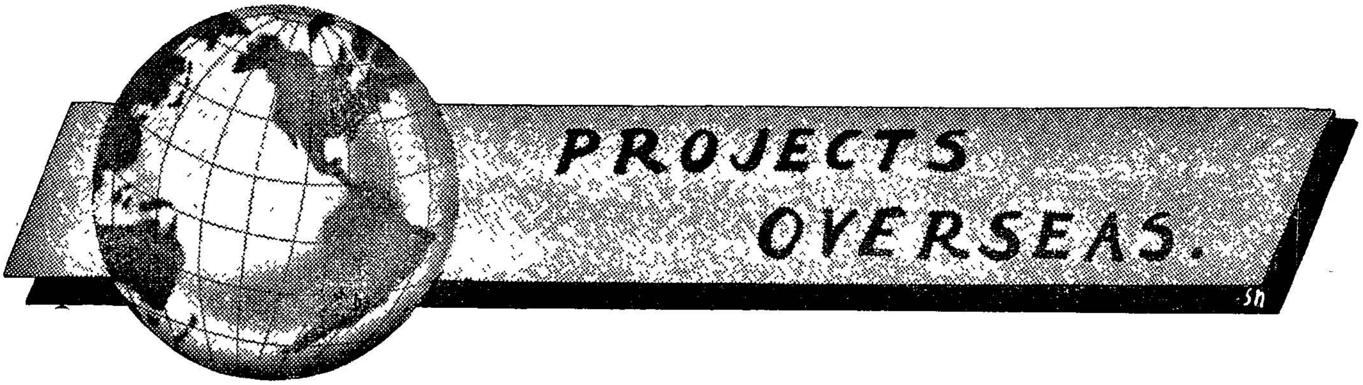

Rolled Earth Fill Construction Methods for Neversink Dam

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(*Continued from last issue*)

Placing Screened Earth

Materials were placed on the fill in windrows parallel to the dam axis from bottom-dump wagons. All such wagons were designated by fill class with luminous colored tags, suitable for night work. Dump gates were set to open a uniform width. To the extent possible, windrows were contiguous, and spaced 12 ft. and 14 ft. distant for Class A and Class B materials, respectively. Windrows were spread with a bulldozer to loose depths of 7 and 8 in. for the above fill classes. Following this, a motor grader was used to produce a smooth surface, conforming to the transverse slope desired. Tire marks were then removed with a tooth scarifier attached on the rear of a tractor, and the fill was ready for compaction.

Compacting Earth Fill

Rollers were of the two drum articulated type equipped with cleaner bars; each drum 60 in. diameter, 60 in. length, weight 2100 lbs. per linear foot, empty. Teeth or feet 8 in. long were specified in a staggered pattern, one foot for each 110 sq. in. of drum area. Permissible foot area ranged from 5 to 6 sq. in. When coupled in tandem, trailing drums were offset to avoid tracking in the foot-patterns of the leading drums.

The fill was rolled with 14 and 8 passes, respectively, for Class A and Class B embankment. Except as noted, rolling was performed in flag-marked paths paralled to the dam axis, at a maximum speed of 220 ft. per minute. Adjacent paths were overlapped 12 in. The fill was rolled parallel to the abutments for a width of about 30 ft. to offset the churning caused by short turns.

Rollers were weighted with water to obtain substantial penetration to the full depth of the foot. Usually, the total roller weight resulted in a static foot pressure of 650 psi., assuming full bearing on four feet.

Roller compaction was obtained against the straight batter sections of the concrete cutoff wall by sloping the fill surface on a 5 per cent grade away from the dam axis. This permitted roller feet to approach within a few inches of the wall.

Relatively small areas, inaccessible to the rollers, were compacted with a one-man, portable tamper, operated by a small gasoline motor. Larger stones were raked out, and soil compacted in 2 inch layers. Coarse materials next to the rock fill were placed unscreened and spread in the usual manner. Large stones were then

pushed into the rock fill with a heavy rake attached to a bulldozer frame.

In the Class A fill, 4 drums were usually pulled by one tractor, operating in third gear. Only two drums were pulled by the same tractor in the granular Class B Fill, due to difficulty in turning at the abutments.

Between layers, the fill surface was thoroughly loosened with tooth and disc harrows. Several trips were required in the Class A areas to break up surface compaction resulting from traffic on the fill. This was an important task because experience indicated that a new layer would not bond to a hard crust.

Screening Plants for Pit Soils

Grizzly Plant	No. 1	No. 2	No. 3
Dist. to centerline of dam by haul road ...	(ft.) 3,000 +	3,000 +	3,000 +
Dist to borrow area ...	(ft) 1000 to No. 2 (miles) 1 + to Kort-right	500 to No. 2 . 1 + to Kortright	2 + to Irwin
Elev. Upper decking ...	1332 ft.	1,404 ft.	1,326 ft.
Elev. road where trucks to dam are loaded.	1284 ft.	1,340 ft.	1,300 ft.
Elev. road where rejects are loaded ...	1284 ft.	1,340 ft.	1,270 ft.
Length of slot in decking over receiving hopper ...	one at 27 ft.	Two at 25 ft.	Two at 38 ft.
Type of screens ...	2flat vibratory	2 rotary	2 rotary
Inclination of screens (degrees from hor.)...	14	9	8
Size of screen ...	5'×12'	7' diam.×23' lg.	7' diam.×23'
Total No. 6"×6" square openings in screens	288	1800	1,320
Motor on each screen ...	20-hp. 440 volt G. E. motor	50-hp. 440 volt Allis-Chalmers motor	40-hp. 440-volt Allis-Chalmers motor
Type of pan feeder hopper to screen ...	All 3 plants have Jeffrey type 5 pan feeders		
Capacity of receiving hopper (cu.yd.) ...	2 at 35 each	2 at 175 each	2 at 100 each
Capacity of processed material hopper (cu. yd.) ...	2 at 36 each	2 at 220 each	1 at 500
Capacity of reject hopper (cu. yd) ...	2 at 18 each	1 at 50	2 at 50 each
Gate on processed material hopper ...	All 3 plants have horizontal rubber belt, roller gate operated by a compressed air ram		
Gate on rock hopper ...	Electric tugger hoists	Apron feeders powered by 75 hp. 440 volt Crocker-Wheeler motors Rock gates operated by hydraulic rams. Powered by 20 hp. 440-volt G. E. motor	Apron feeders powered by 75hp. 440-volt G. E. Motor. Rock gate operated by Sheppard Niles 75 hp. 440-volt motor
Conveyor Belt ...	(none)	(none)	Width 60"; thickness 1"; length c. to c of end pulleys, 325 ft.; rise, 75 ft. Powered by 2 Westing-house 250-hp. 2,300-volt motors rated speed, 600 ft./min
Best Performance (cu. yd. per 8-hr. day) ...	6,000	13,000	9,000

Smooth Rolling, Reduction of Fill Moisture

For drainage purposes, the fill surface was sloped transversely from the dam axis on grades ranging from three per cent to seven per cent. Impervious and semi-impervious areas were smooth rolled to a hard crust between work shifts or when rain threatened. This work was performed with weighted drum rollers, similar to those described above, except for the absence of feet.

An average rainstorm saturated about one inch surface depth of the smooth rolled Class A fill. In clearing weather, the mud was scraped off in windrows with road graders, and was picked up with earth scrapers and spread in layers 2 ft. thick on the downstream weighted area, where it was eventually compacted by tractors.

Smooth rolling of semi-impervious areas was of relatively less benefit. After rainstorms, these soils required discing for the reduction of moisture content. Precautions were taken to prevent saturation of the fill by rainfall prior to smooth rolling. Particularly in the impervious areas, discing was of little immediate value in such cases. Usually, it was more practicable to remove the top layer of fill as described above and start over again.

Judging Quality of Fill Compaction

Minimum compaction required in the Class A fill amounted to 97 per cent of that which could be obtained in accordance with prescribed practices, under the most favourable field condition.

A compaction criterion was established during the early part of the work when the amount of fill placed per shift was small in volume. Relatively large numbers of density determinations were obtained and the unit dry weights of each sample, less then the ¼ inch size, were dublicated in the laboratory. The soil was compacted in three layers in a cylinder mould, 1/30 cu. ft. in volume.

On the average, it was found that 30 blows per layer of a 5.5-lb. hammer, falling 18 in., were required to match the unit fill weight at a given moisture content. Curves of unit dry weight versus moisture content were obtained for representative soils by this method. For a given soil, minimum required fill compaction was assumed as equal to 97 per cent of the unit dry weight corresponding to optimum moisture content.

Average optimum moisture content was 9 per cent, and the density criterion permitted campaction of the Class A fill at contents ranging from 7.5 per cent to 10.5 per cent. Before rolling, wet fill materials were aerated with disc harrows until the moisture content was reduced to the maximum given above. Vigorous discing with 4 harrows effected a moisture reduction of about 2 per cent per hour, under favourable atmopheric conditions: provided initial moisture was not more than about 13 per cent. In general, discing was practiced at all times when the fill moisture was intermediate between optimum and 10.5 per cent. However, in such cases, compaction was not delayed.

It should be noted that the project is located in an area of relatively humid year-around climate, hence aeration rather than sprinkling was the prevailing need.—(*Editor.*)

Unit fill weight was determined by tests of materiels recovered from the second, third and fourth layers beneath the surface. In the impervious and semi-impervious areas, a cubical chunk, about 12 in. on a side, was obtained by hand excavation. Chunk volume to the nearest 0.001 cu. ft. was obtained by oil displacement. The materials were then separated at the ¼ in. size in a circular screen, operated mechanically. It was necessary to determine the weight and absolute volume coarser than this size in order to find the unit dry weight of finer materials. The latter soils were compacted in the cylinder mould at fill moisture content, as described above.

Good construction practices were indicated if unit dry weight of the fill sample, less than ¼ in. size, was equal to that obtained in the laboratory. Otherwise, the need for rerolling was indicated.

Unit fill weight in the granular Class B areas was determined by a rubber baloon volumeter. Otherwise, the procedure was similar to that described above, except that hammer blows per layer were reduced from 30 to 20 in number.

Average Fill Compaction

Average compaction obtained in the fill and laboratory at the fill moisture content are given in the table.

In all, 2151 samples were recovered during the placement of 7.5 million cubic yards; or an average of one sample for each 3500 cu. yd. Class A compaction, less than ¼-in. size, amounted to somewhat more than 98 per cent of maximum laboratory compaction at optimum moisture content.

Other things being equal, best compaction was obtained when the following practices were observed: (1) earth windrows spread to uniform thickness (2) roller paths flag-marked to obtain a small overlap, and (3) top layer of fill thoroughly disced and aerated before placing another.

Typical Results of Compaction Effort

Year	Class of Fill *	Samples Recovered	Moisture Content %	Unit Dry Weight-Lb./cu ft. — Fill — Complete Sample	Fill — Less than ¼" Size	Lab Less than ¼" Size	Optimum Moisture Content	Weight Coarser than ¼" %
1948	A	129	8.7	135.5	129.5	131.6	8.9	20
1949	A	523	8.4	136.9	130.6	130.9	9.1	21
,,	B +	457	8.6	136.4	126.9	127.0	—	30
1950	A	580	8.2	136.4	130.2	129.8	9.0	20
,,	B +	286	8 0	136.5	129.5	127.9	—	23
,,	B	158	8.8	136.7	122.6	124.1	—	42
Class	A	1232	8 4	136.2	130.2	130.2	9.0	20
Class	B +	761	8.4	136.4	127.8	127.2	—	26
Class	B	158	8.8	136.7	122.6	124.1	—	42

*B+is semi-impervious soil, B is pervious. In laboratory tests, hammer blows per layer were reduced from 30 blows to 20 blows for these materials.

Testing During Construction

To a large extent, tests performed on materials less than ¼-in. size were limited to those required to obtain desired soil classes, to control moisture content, and to measure compaction, as described above. Moisture samples were dried with a battery of twelve 250-watt infra-red heater lamps. In a period of 10 minutes, such a lamp evaporated the same amount of water from a given soil as an electric oven, thermostatically controlled at 105° C. Drying time in the oven averages about 2 hours. Percentages of clay finer than 0.005 mm, were obtained with a top-type specific gravity hydrometer in a period of 1 hour. A summary of control tests performed in the laboratory is given below:

Description of Test	Number of Tests Performed
Fill compaction ...	2,151
Laboratory compaction ..	2,480
Clay content ..	5,120
Moisture content ..	11,480
	21,231

Laboratory tests were supplemented by visual analyses of clay and moisture contents. Such analyses were recorded and compared with actual test results. With practice, relative errors in clay estimates averaged 2%±, and in moisture estimated 1%±. On the average, a test of one kind or another was performed for each 330 cu. yd. of compacted fill.

Measurement Installations

Field installations for measurement of movements and hydrostatic pressures include *12 foundation settlement plates*, equally divided between three transverse sections. These are located 75 and 235 ft. upstream, and 100 and 400 ft. downstream. During construction, steel casings were carried up from the plates concurrently with the dam surface in order to obtain intermediate measurements. When the dam was topped off, *foundation settlements ranged from 1.25 ft. at points nearest the dam axis to 0.5 ft., at the most distant points.* It is estimated that approximately 95 per cent of the ultimate settle-

ment occurred during the construction period. Fixed observation points were placed adjacent to upstream and downstream toes. These have indicated negligible horizontal and vertical movements of the foundation surface. Since topping off, additional surface points have been estabilished in the vicinity of the crest in order to measure residual dam settlement and lateral creep.

Hydrsotatic pressures are measured by piezometers of U. S. Bureau of Reclamation design. During the construcion period, 23 such piezometers were installed at 4 levels along a section transverse to the dam axis. Piezometer locations were selected as to obtain maximum information concerning seepage through the dam and downstream foundations during the service period.

Essentially, a piezometer of this type consists of a hallow plastic cylinder, or tip of 1-in. in diameter and 1 in. length, open on one end. It is connected to valves and pressure gauges located downstream by means of 2 lines of 5/16 in. o.d. plastic tubing. Tubes enter opposite sides of the cylinder so that the system can be filled with water from the downstream terminal well by circulation through the tip.

Hydrostatic pressures from the fill gain access through a porous disc fitted in the open end of the plastic tip, and are measured independently by a gauge attached to each line of tubing. Tips and tubing are laid in earth trenches, and stones are removed from backfill around the tubing in order to protect it from damage.

The downstream pump sumps were adapted for hydrostatic pressure measurements by extending a 2-in. steel pipe from each sump to pressure gauges located downstream. Sumps were partly filled with porous material and capped with concrete below the watertable elevation. In one sump, porous material was placed between a concrete base and cap so that access to the pipe would be limited to hydrostatic pressures from the impervious fill. Sumps and connecting pipes were filled with water introduced from downstream.

Hydrostatic pressures resulting from settlement of the dam under its own weight, as well as from foundation settlement, have been observed weekly since May, 1950. On the average, pressure in the impervious fill increased as the fill surface was raised, although not usually at the same rate. It was considered that intermittent pressure increases were associated with the progressive nature of soil settlement. Maximum hydrostatic pressures were equal to about 40 per cent of the overlying fill weight and early in 1951 had diminished to about 30 per cent on the average.

Contractor's Equipment Used on Neversink Dam Project

A table of equipment used on various parts of the work is given below: (* Indicates equipment new in 1949.)

Excavators

- 2 Bucyrus-Erie steam shovels, model 50B, 1½ yd.
- 1 Bucyrus-Erie electric shovel, model 120B, 5 yd.
- 2 Bucyrus-Erie diesel shovels, model 54B, 2½ yd.
- 11 Bucyrus-Monighan dragline, model 200W 6 yd.
- *2 Marion electric shovels, model 4161, 5 yd.
- 1 Northwest diesel shovel, model 80D 2 yd.
- 1 Northwest dragline, model 80D, 2 yd. Also backhoe
- 2 P & H diesel shovels, model 1600, 6 yd.
- 1 P & H diesel shovel, model 6DC, 3 yd.
- 2 P & H diesel shovels, model 1400, 5 yd.
- 2 P & H diesel shovels, model 1055, 3 yd.
- 1 P & H diesel shovel, model 955, 3 yd.
- 2 Lima diesel shovels, model 1201, 3 yd.
- 1 Lima diesel shovel, model 234, 3 yd.
- 1 Lima diesel conv. to electric crane, model 34 (cherry picker)
- 2 Koehring diesel cranes, model 803, 60-ft. boom
- 1 Lorain truck crane, model, MC 414
- 3 Lorain truck crane, model 6x6 (40-ft. boom)
- 1 Wayne crane, model 22
- 1 Hughes-Keenan swing crane, model MC 2H
- 1 Traxcavator-Caterpillar, model D7
- 1 Ford-Ferguson end loader
- *1 Euclid loader, model 13-VB-51

Tractors, Graders and Scrapers

*4 Caterpillar tractors, model D8
11 Caterpiller tractors, model D8
4 Caterpiller tractors, model D7
6 Allis Chalmers tractors, model HD19
10 Allis Chalmers tractors, model HD14C
4 International tractors, model TD18
3 Tournadozers, model C-1
3 Tournadozers, model C-2
4 Tournapulls, model H210 (used with Carryall scrapers)
8 Le Tourneau carryall scrapers, model LP
1 Adams grader, model 512
1 Austin Western grader, model 99H
4 Caterpiller graders, model 12

Trucks

3 Autocar tractors
5 Auto trailers
*2 Brockways
2 Chevrolet bomb carriers
*2 Chevrolet pickups
16 Chevrolet pickups
1 Dodge stake
2 Dodge weapon carriers
1 Ford bus
1 Ford panel (ambulance)
*1 Ford service
3 Frehauf trailers
1 G M C panel
1 G M C pickup
1 G M C stake
1 G M C dump
1 International flat
3 International pickup
4 International tractors
6 Jeeps
*1 Rogers trailer
1 Rogers trailer
5 Studebaker flat 1½-ton
1 Studebaker full tank
2 Studebaker sprinklers
1 Studebaker dump
1 Sterling truck tractor
*4 Trailmobile trailers
2 White flat (10 ton)
*1 Kentucky platform trailer
1 Rogers semi-trailer

Earth Wagons

31 Euclid rear-dump wagons; 15 were 9.7 yd, 8 were 14.5 yd., 8 were 14.8 yd.
141 Euclid bottom-dump wagons; 84 were 13 yd, 3 were 16 yd., 4 were 21 yd., 40 were 24 yd., and 10 were 25 cu. yd.

Concrete Equipment

1 Ransom paver, model 34E
1 Ransom mixer, model 14S
1 Blaw Knox batching plant
2 Vibrators (Bridges & Stratton)
1 Master vibrator, 1½-hp.

Drilling Equipment

2 Ingersoll-Rand quarry master drills
2 Bucyrus-Erie well drills 29T
1 Bucyrus-Erie well drill 27T
6 Gardner-Denver wagon drills
*1 Gardner-Denver wagon drill

Pumping Equipment

There were on hand 30 pumps, used occasionally as the need arose: These included the following makes:—Ingersoll Rand, Pomona, Westco, Weinman, Gorman-Rupp, Jaeger, Labour, Gardner-Denver, Myers, Morris, Kelly and Worthington.

Miscellaneous Equipment

*2 Sets double tandem disc harrows, 24" (Rome plow)
3 Sets double tandem disc harrows, 24" (Rome plow)
14 Sheepsfoot rollers (2 sections)
*1 Sheepsfoot roller (2 drum tandem)
4 Flat rollers (3 sections)
4 Huber rollers, model D4400 (10-ton)
1 Rooter LeTourneau, model K-30
*2 Fleco rock rakes
5 Hand tempers
*2 Markley dust collectors (new), model 4
1 Markley dust collector (used), model 4
*1 Caterpillar diesel generator (portable), model D1300
*1 G. M. diesel motor generator (portable)
3 O'Keefe & Merritt generators (portable), model 6016E
2 Onan generators (portable), model O & AHIM
2 Ingersoll-Rand compressors (portable), model IR315
1 Ingersoll-Rand compressor (portable), model IR318

1 Ingersoll-Rand compressor (portable) model I-XAK
1 Gardner Denver compressor, (portable), model ACDI
1 Sullivan compressor (unmounted), model E
1 Sullivan compressor (on skids), model D1300
3 P & H Portable gasoline-drive-powered welders, 300 amp.
*4 Lincoln welders, 300 amp. electric
5 Lincoln welders, 300 amp. electric
1 Lincoln welder, 500 amp. electric
2 Hobart welders, 300 amp. electric

Garage and Machine Shop

1 Northern overhead traveling crane (10 tons) outside of building
1 P & H overhead traveling crane (5 tons) inside of building
1 120 ton Rogers hydraulic press
1 100 lbs. pressure, Rogers hydraulic press
1 Press (Land Machine Co.), model E-F-22Y
1 Caterpiller service press, model 486
1 Canedy drill press T2235
1 Famco press
1 Press, S49 (Manly Div. of American Chain)
1 20" lathe (American Tool Works) rebuilt type H
1 Lathe Mfg. by Lodge & Shipley Machine Tool Co.,
1 R. K. Le-Blonde lathe
1 Drill Steel cutter shank griner S2500
1 Gould & Eberhardt shaper; W/Brown Brockmyer motor
1 Brown and sharpe milling machine Mod. 3A
*1 Buffalo Forge Co. (Universal Iron Worker)

(Miscellaneous electric grinders, valve seat grinders, electric drills, sanders, etchers, air wrenches, power blow hammers, electric steel saws, vises, welding accessories and sets of the following: reamers, arbors, pipe taps and stocks and dies.)

1 Airco radiograph cutting torch
1 Track wrench, Rogers hydraulic model TW
1 Rebuilder lbs. 8 Mfg. by Accurate parts
2 Alemite pumps, model 6521
1 Hydraulic pressure bleeder (automatic Corp.)
1 Hydraulic brake pressure flusher
1 Barrett Heavy-duty brake reliner and grinder, model B51
*1 Malsberry steam Jenny, model 322
27 Jacks from 10 to 70 tons (some new in 1949)
1 Pipe master (threader and cutter) W/2 HP Lamb motor
1 Oster pipe threader
1 Pipe cutter (hand) Sw-3 wheel Reed
1 Toledo hand pipe threader
1 Pipe threading machine (Jarecki Mfg. Co.)

Heating Plant for Garage, Machine Shop and Warehouse

Two boilers are connected up in this heating plant. One is a * Pacific boiler with a York oil burner, model C-55 with a Peerless motor lbs. 781920. Steam capacity lbs. 2500 per hour, maximum pressure 15 psi. The other boiler is a Kewanee Type C with a Burnrite oil burner. The return line is equipped with a Wagner electric motor. There are in all 22 Dunham heater blowers, on 4-in. steam lines branching off a 6 in. main.

Compressor House

1 Sullivan compressor, model WN114, 2-stage powered by 400-hp synchronous motor
2 Ingersoll-Rand compressors, imperial type 10XRE powered by 175-hp. G. E. motors
1 Ingersoll Rand compressor converted from steam to electric-Imperial type 10 GE synchronous motor, 175-hp. Serial 5505472
1 Westinghouse motor generator unit style 1034614

Heating Plant:—Gold Star oil burner model R117 in Kalamazoo Stove Company type Admiral hot air furnace.

Servicing & Lubricating Building

2 Compressors, Brunner, model H7588, type A with motors
6 GE Tungar battery chargers 6RB 681 amps. 110 volts 115

- *1 Weaver twin post lift 2 Be 2410 with 5 hp. GE motor
- 1 Deming pump W/Westinghouse motor and tank
- 1 Gardner-Denver pump AE 35
- 1 Hilco oil line purifier, model A-12
- *1 Lincoln portable Lubrovan unit, model 26; is mounted on grease truck

Heating Plant

- * Two Dravo counterflow heaters Cat. lbs. 50-HO with GE motors, motor model C1638 W/fans

Tire Shop

- 1 Curtis compressor (gas driven) size 4×8/16×21/8×3½
- 1 Ingersoll-Rand compressor WP 250 HSB 7609
- 1 Onan electric plant, model 07AHIM
- 1 Tire spreader for Euclid wagon tires
- 2 Yale 3-ton spur geared hoists W/single track trolleys
- 1 Blackhawk jack, model P76
- 1 Simplex jack, model lbs. 22
- 1 Hydraulic jack (on rollers) 4 tons

Electric Shop

- 1 Atlas electric drill press, model 54
- 1 Thor B68 Bench grinder, model 5714. ¼hp. motor
- 1 Pipe threader (Toledo) lbs. 884
- 1 Heyer battery charger with stage switch 7-12
- 1 Rubber cable vulcanizer (Mines Equipment Co.) type 3G AS
- 1 American Engineering Co. 2-ton electric hoist, model C-5072 IH single trolley
- 1 Rock island bench vise
- 2 Electric Malls mfg. by Mall Tool Co., model 80-D
- 2 6 ton Coffin hoists
- 1 1½ ton Coffin hosit
- 2 ¾ ton Coffin hoists
- 2 Yale 1 ton chain hand hoists

Heating Plant

The electric shop is heated by a gun type *Gold Star oil burner with a Thormaster hot air furnace (no ducts)

Carpenter Shop

- 1 Chain saw, Kiekhaefer Corp. model KB6AY, gasoline powered
- 1 Disston chain saw, gasoline engine
- 1 Skillsaw electric, model 87
- 1 Radial saw (Walker Turner Co.)
- 1 Electric band saw with bench
- 1 Bench vise 974½ Parker

Heating Plant for First Aid Engineer and Time Office Building

Hot water heat is furnished to this building by a Petro Oil burner model A4345-C-3-9, gun-type feed. This system has a tubular boiler (International) Type C, size 526. This plant is in a small detached building. A 4-in. line conducts the hot water to the above building, where there are thirteen radiators ranging from 6 to 28 sections and from 2 to 3 ft. in height. The hot water supply in the taps is provided by a 60-gal. tank connected to the boiler.

With acknowledgments to "World Construction," May-June, 1951.

Meshwa Canal Project, Bombay State.

Meshwa Canal Project in Kaira District is the first one to be put into commission under Post-War Reconstruction and Development Programme for Major Irrigation Works in the State of Bombay. It proved its utility in the very first year of its existence and saved the drying paddy crops to the extent of about 9,000 to 10,000 acres during last August when there was almost an unprecedented dry spell of weather.

2. The project envisages utilisation of the waters of Meshwa river for irrigation in Kharif season to the extent of 18,000 acres of land in Kaira District. There would be some Rabi irrigation also, depending upon the postmonsoon flow and rainfall during the year.

The average rainfall is about 30 inches but generally it is not well distributed and failure of September rains is a matter of common occurrence. Paddy is a principal Kharif crop of the tract and often it failed without a proper irrigation system to protect it.

Nearby is the Khari river and on its tail there exists on its delta a very old irrigation scheme, *viz.*, what is known as Khari sluice system of Kalambandhi group of villages. About 7,000 to 8,000 acres of rice fields of these areas are well-known for variety and yield of their crops. They depended upon the Khari river which is about half the size of the Meshwa. Just further upstream, there is similarly developed area under old irrigation scheme known as Khari Cut Canal system comprising of about 12,000 acres of first class rice fields. But as the Kalambandhi areas had established their riparian rights on the natural waters of Khari river by a High Court decree, areas on the Khari Cut Canal system suffered for want of sufficient water from the Khari river. The administration, of Hathmati and Khari Cut Canal system always proved a difficult problem in practice. Therefore it was a long felt necessity to divert if possible the Kalambandhi area on another system. The Meshwa Canal project serves the purpose.

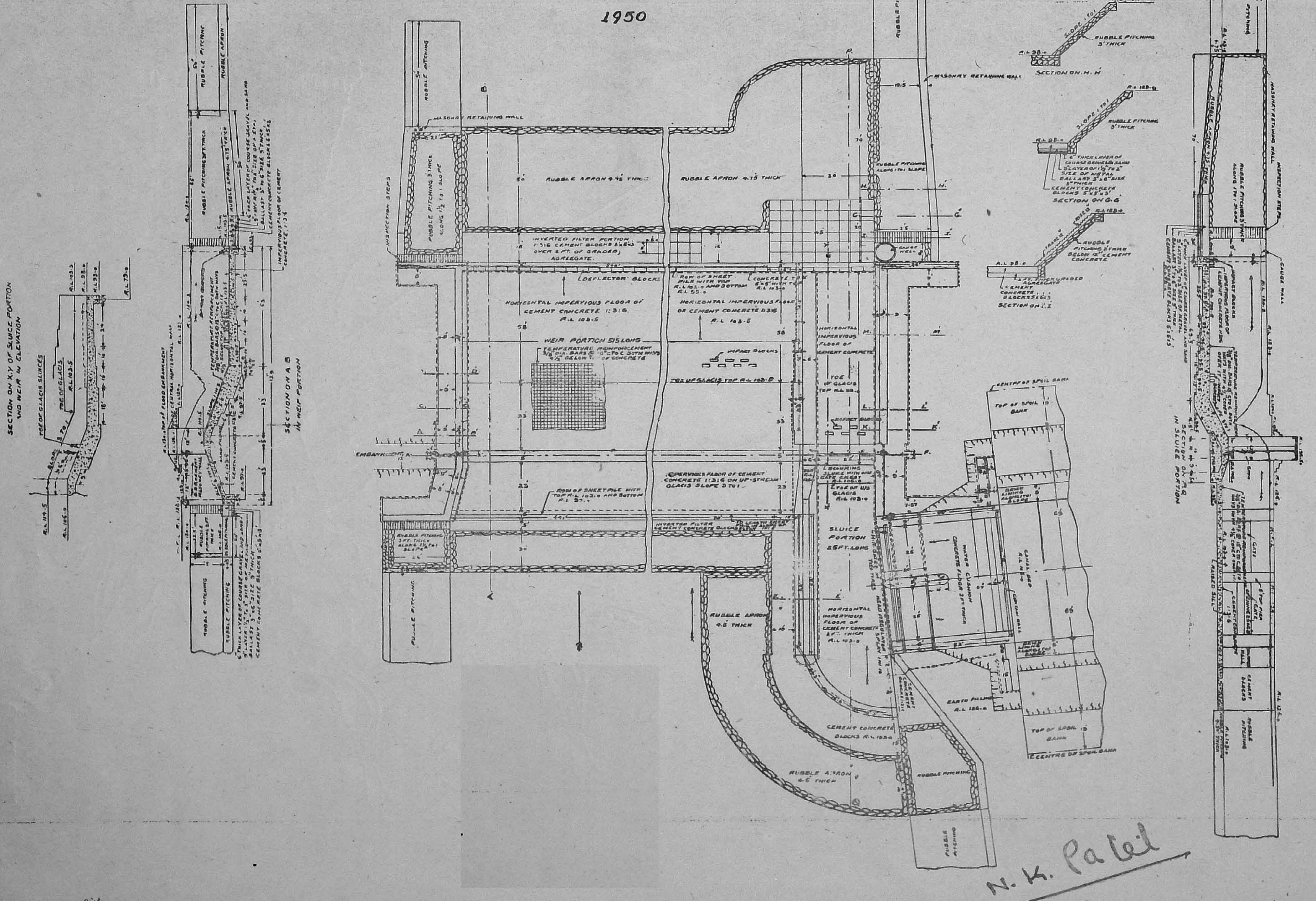
The Meshwa is a non-perrenial river. The Meshwa Canal Project comprises of a pick-up-weir across the river near the Raska village about 6 miles, east Barejadi station on the B.B & C.I. Railway. There is a right bank canal about 9 miles in length, bringing under its command the rice areas of Mahij, Lali and Bidaj villages to the extent of 1,200 acres. Two first class existing irrigation tanks, namely Galki and Gobhlaj, are fed by the canal and thus about 800 acres under Galki tank in place of about 400 acres at present and about 1,800 acres under Gobhlaj tank in place of 800 acres at present can be brought under command. Thus these areas would get assured water supply and they shall not have to depend upon the uncertain replenishment from their own small catchment areas. The main canal is led into the Khari river about the Kalambandhi areas to ensure to these areas a supply of about 75 cusecs as per agreement with those irrigators.

A branch canal about 15 miles in length runs to irrigate on its way the lands of Wasna, Samadra, Kajipura and Radoo villages situated between the Meshwa and Khari rivers. The area under command of this canal is 18,000 acres. Thus the

MESHWA CANAL PROJECT

DESIGN FOR SOLID PICK-UP-WEIR

1950



PREPARED BY -
TRACED BY -

N. K. Patel

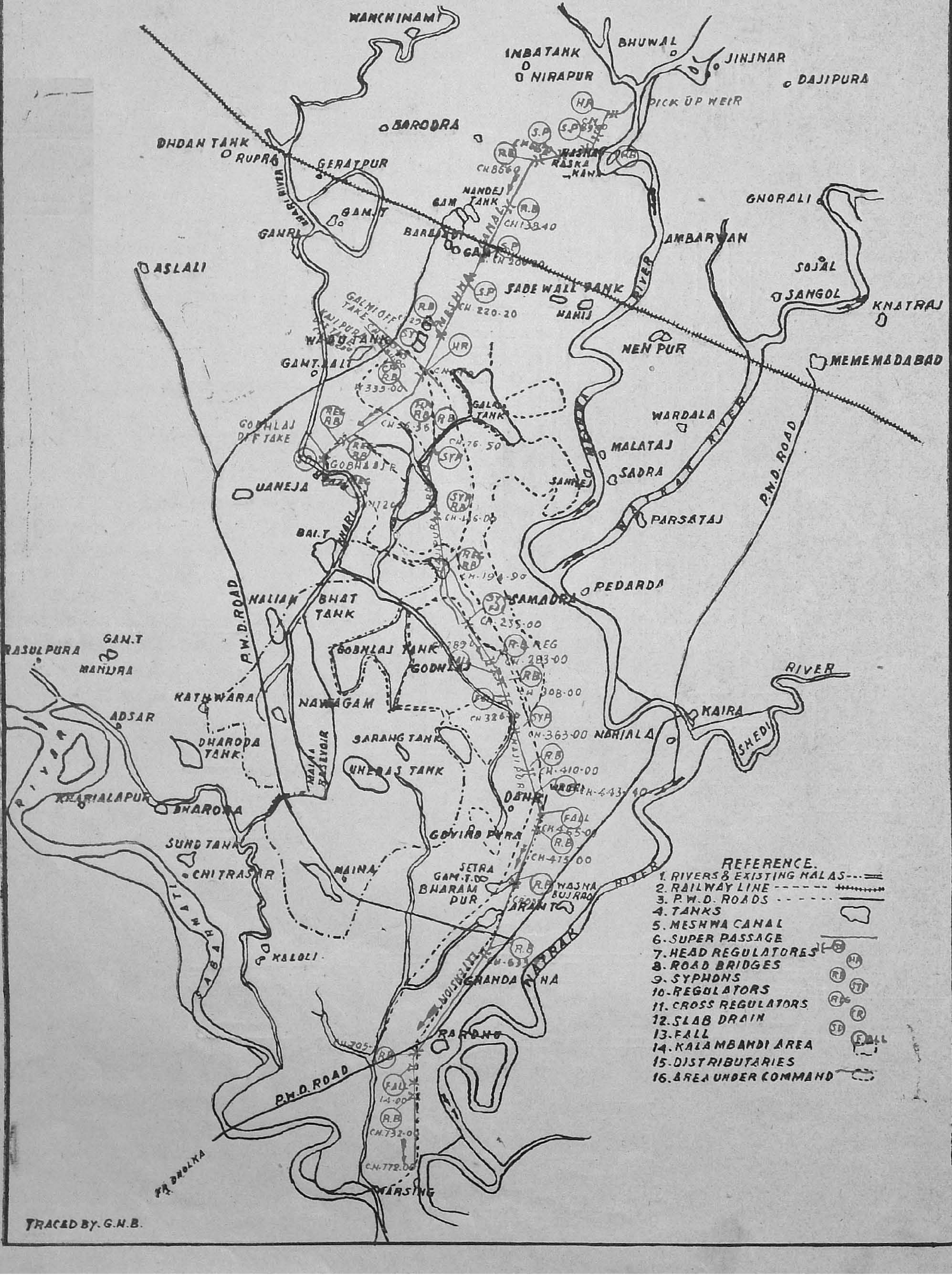
EXECUTIVE ENGINEER
AHMEDABAD IRRIGATION DIVISION

MESHWA CANAL PROJECT

INDEX PLAN

SHOWING CANAL LINE CROSS DRAINAGE WORKS & AREA UNDER COMMAND

1950



Meshwa Canal Project serves the areas as follows :—

(i)	Direct Irrigation on Main Canal ...	1,400 acres.
(ii)	Areas under command of Galki and Gobhlaj Tanks.	2,600 acres.
(iii)	Direct Irrigation on Kajipura Canal ...	6,700 acres.
(iv)	Irrigation of the Kalambandhi areas	7,300 acres
		18,000 acres.

The pick-up-weir consists of mass cement concrete (proportion 1 : 3 : 6) work with upstream and downstream cut off walls of iron sheet piles. It is designed in accordance with the theory developed in publication No. 12 of C.B.I. on "Weirs on Permeable Foundation." The design was scrutinized by CWINC. The weir is 129' wide at the bottom and its height 10½' above bed level. The top of the weir is 5' wide with parabolic shape giving increased coefficient of discharge. On the right end of the weir combined with the Head Regulator, a river sluice 25 ft. in length is located to provide for reduction in the silt charge of waters passing into the canal and to scour the silt gathered in front of the openings of Head Regulator. A divide wall is constructed to form a distinct sluice channel and is extended right upto the front of openings of the Head Regulator. The Head Regulator is sited little oblique with a slant of 1 in 10. It consiste of two spans of 25' length provided with steel gates in two tiers. The gates sliding on rollers are to be lifted by sprocket chains and are to be operated by proper gearing arrangements. The work of construction of steel gates was undertaken by Government workshop at Vijayawada, Madras State.

The main canal is designed for a capacity of 334 cusecs and is 18' wide at the base and with 6' F. S. Depth and bed slope of 1 in 4,400. The Branch Canal is designed for a discharge of 110 cuses at its Head and has a bed slope of 1 in 4,000.

The above are the principal features of the project and it will not be out of place to give a few details about its construction side. The monsoon of 1948 was one of the worst on records. The monsoon of 1949 was also not a favourable one and the entire rice areas of the tract suffered almost total failure. The plight of the farmers in these difficult times became bad enough. Therefore it was ordered by the Government of Bombay to give the project highest priority and to put it into commission by June 1950.

The work of construction of canals was started in the begining of 1948. The important portion of the main Canal involving total earthwork of 18,185,100 c.ft. was completed in about 12 months. It involved deep cutting upto 25' and more in sufficiently hard soil and was completed entirely by manual labour.

The work of the pick-up weir and Head Regulator was started in the middle of November and completed in the beginning of July in about 7½ months.

The work was completed in time and during the year the Weir was tested fully by one of the highest floods that occurred in last September.

There were several cross drainage works, distributaries and outlets distributed in about 25 miles length on the canal system which were started by middle of February and were generally completed by end of June 1950.

The total cost of the project would come to about Rs. 50 lacs Since it ensures an unfailing supply to the existing irrigation areas of about 9,000 acres of rice in Kalambandhi areas and under command of Galki and Gobhlaj tanks, its value in increased food production would be about (9,000 x 1/3 :) 3000 tons. The food production from the additional areas that it would bring under irrigation would be (9,000 x 2/3 :) 6,000 tons. Therefore in all 9,000 tons of additional food production worth about Rs. 40 lacs would be secured.

Its indirect benefit in making the Khari Cut Canal system independent of the Kalambandhi area and allowing development of the former area is substantial.

—Reproduced from a Book-let distributed in the Inter-National Engineering Exhibition held in Delhi (1951.)

A Few Rigging Tricks Help Handle Heavy Loads in Close Quarters

BY H. B. McDERMID, *Retired Construction Engineer.*

It often happens in construction work that heavy loads must be hoisted to position close up against a solid ceiling, where there isn't head room to use a hitch of the usual sort. If the load is heavy enough to require multiple parts of hand-operated rigging, then getting a set of chain falls, or even a heavy set of rope blocks, located high enough to do the job is a man-killer. Usually the location is such that only one man can get at the job; and to succeed he just has to be stout, having the ability to punish himself unmercifully to get the hitch placed so that it will do any good. Even such a man will often wonder whether the figures cast on the side of a set of chain falls refer to its lifting capacity or to its dead weight!

An easy way to solve lifting problems of this type came to notice on a power-house job. Some auxiliary steel had to be placed close up to a ceiling. It was just too heavy to place without rigging, but even with every possible inch of head room saved, in placing the tackle, the steel could not be hoisted to within a foot of its designated place. The crew was nearly helpless. They tried hoisting the load as far as it would go with the blocks and then, from ladders, tried to muscle it up that last foot. It was no go—they managed to get a few pieces placed at the price of exhaustion, but the days' work was a sorry spectacle when judged by the pitiless standards of the usual steel worker.

Next day a new foreman had the job. He hunted up a single rope block, as small as he could get; its light weight made it easy to hang close up to the ceiling. Then he rove a single line through it, attached his load to one end and his double rope falls to the other. Anchoring the free end of his falls, far enough away to get plenty of "drift" he hoisted away. The load—an I-beam—went clear up to its location without hesitation, and one after another followed smoothly until the job was done in a few hours. And nobody worked more than was normal.

The writer filed that trick away in his memory and has often used it since. It's a life saver in many instances, In case of a bulky load, it is both wise and necessary to run the single line through a second single block, thus leading the line over to one side out of the path

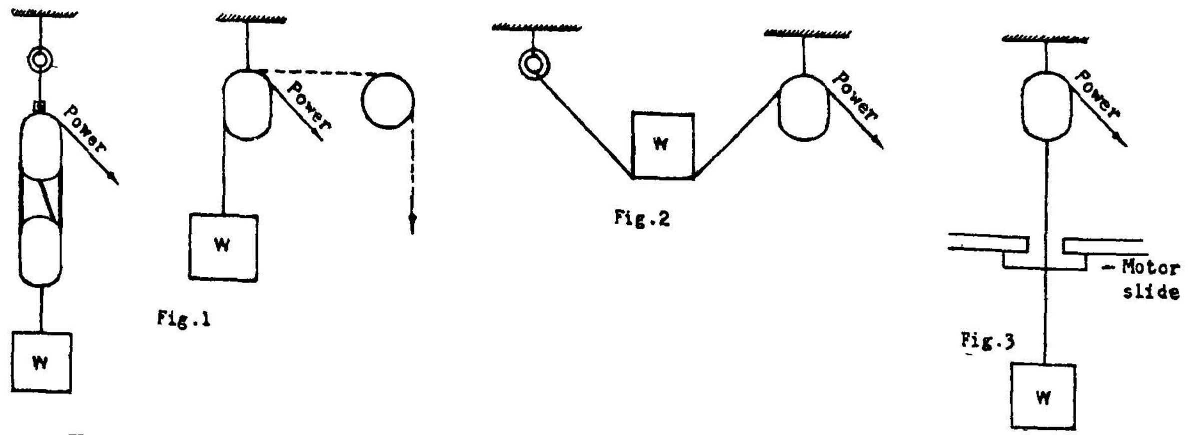


FIG. 1: Conventional falls, even when two-blocked, occupy needed headroom. Single block solves problem, with falls rigged off to one side.

FIG. 2: Load is cradled in line rigged between points on either side, can be placed solidly against ceiling.

FIG. 3: Sometimes hoist can best be rigged through ceiling to floor above.

of the load before hitching up to the rope falls or other power source. The accompanying sketch (figure 1) shows the set-up and how it saves room when used in place of double falls directly above the load.

Sometimes a job comes up which required that a steel member or heavy length of pipe be placed solid against the ceiling. With this problem a different set-up is indicated. If the rigger can secure two hitches against the ceiling, one on each side of the final location (and as close to it as possible), the job can easily be handled. He simply fastens one end of his line to one hitch, passes his line under the load, and reeves it through a single block secured to the other hitch. Power applied to the free end of the line will pull the load up tight against the ceiling, depending on the relative depths of the load and the single sheave of the block.

In the case of a pipe or structural steel member, it will be handy to have one such hitch at each end of the load to keep it in control. Also, as the load cradled in the two rigs will roll over as it goes up, it will be necessary to stop hoisting near the top and straighten the load so that it will arrive in its place right side up or 'workways" as the rigger calls, it. But the load can be pulled tight against the ceiling by this method, which is a handy trick to know when one has need for it (figure 2).

A third method comes to mind. A really heavy piece has to go high against the ceiling, and there is no feasible place to get a hitch below the ceiling. Then, if the floor above is unoccupied, it is a good stunt to drill a hole through the ceiling and place the rigging in the space above, passing a steel cable down to the load. If the set up is correctly made, so as to obtain plenty of hoisting room or "drift" then heavy slow-speed motor, for instance, can be pulled up solidly against its rails or slides.

With this sort of set-up, a disabled motor can readily be replaced by a spare, with a minimum of down time. It is necessary that the motor be closer to its seat than the blocks of the rigging above are to each other. Thus there is no doubt that when the hoisting is commenced, it can go on until the motor is "landed".

—*With acknowledgments to "Western Construction", October 1952.*

The Harrogate Dam Failure

By DELWYN G. DAVIES, B.Sc., (Eng.), M.I.C.E.

The open service reservoir at Harlow Hill is rectangular in plan, but quite small, and unimportant dimensionally. The dam, constructed 83 years ago, consists of a "normal" earthen embankment with clay core supported by "selected fill" and a maximum height of 29 ft. above natural ground level at the junction between the east and north embankments. The upstream and downstream faces have a slope of 1 in 1.9, terminating at the eastern downstream toe with a 4 ft. concrete retaining wall contiguous with the public road. Two separate draw-off pipes, one with a valve tower, pass through the embankment some 4 ft. and 7 ft below top water level. The reservoir has been twice inspected and approved under the Safety of Reservoirs Act, 1930.

In December, 1951, a major downstream slip was discovered where the dam is highest. A vertical movement of 12 in. on the suspected slip plane had already taken place adjacent to the core wall, whilst the toe had uplifted about 9 in. against the retaining wall. In plan, the slip was elliptical with a short axis, from the toe wall to the crest of the slip, of 53 ft. and an eventual contour axis length of 80 ft. During failure, the development of a major slip in a clay embankment was studied. Its first stage consisted of a change in the straight batter of the embankment, a perceptible bulge showing two thirds of the way down the bank. This was followed by a small crack formation just below the top of the batter, and this crack gradually extended along the contour, curving down the embankment to disappear in the slump of the lower half. These cracks, first beneath the soil and then later through it, were detected by fixing two posts with U-shaped top sockets, one near the top of the bank and one 20 ft. down, across which a metal tube of sufficient cross-section to eliminate sag was placed. The tube rested against the socket of the bottom support and was free to slide within the U-shaped top socket. As the inclined tube was clearly marked near the top, any downward movement created by separation of the structure was detected.

Trial holes and borings proved that the major slip plane possessed a thickness of ½ in. of "porridge" clay and was curvilinear on both axes. The amount of moisture required to maintain the lubrication of the slip was very small.

Although a total of one major and four incipient slips occurred, none was contiguous with another. Reasons may be advanced why a gap must exist between one slip and its neighbour. The slips in closest proximity were those at the corner of the reservoir, where the embankment is highest. The stability influences of a right-angle corner in an earth dam are probably dangerous.

The only large stony material (2 in. to 6 in. boulders) in the embankment was found at the top of the major slip below the soil. It is questionable whether this had been deliberately placed along the contour for 10 ft, as a drain, but there is no doubt that it contributed to failure by acting as a reservoir to feed concealed shrinkage cracks.

Some people believe that an earth dam gradually improves in strength and shear resistance and therefore its factor of safety rises. This is only a partial truth. In the initial stages, the earth dam does gain strength with consolidation, probably during the first twenty years; it is probably weakest immediately after construction. When the same structure is viewed after half a century, the picture changes. After final consolidation is reached, the structure imperceptibly weakens year by year. If it did not, then every earth dam would stand for ever. The "adult" weakening takes four distinct forms:—

(*a*) Severe drought shrinks the clay fill, the shrinkage proceeding in a downhill direction. During drought the deepest point of the water table below the surface will occur below the top of the downstream batter.

(*b*) These activities are accentuated by the gradual creep downwards of the surface soil towards the toe. In time this creep causes small tension cracks in the upper parts of the batter and these cracks allow rain water to enter the clay shrinkage cracks.

(*c*) Within the clay core, the slow movement of water passing through it gradually takes out of solution any salts in the clay, possibly by a very slight base-exchange process. The top part of the clay core suffers successive drying and wetting, as dictated by changes in the water level.

(*d*) The drainage system declines in efficiency.

Vertical contour cracks are therefore inevitable at the top of a downstream solpe of any material which shrinks with declining moisture content. This theory was confirmed when a trench cut through a stable part of the embankment disclosed vertical contour cracks below the soil at the top of the downstream batter.

The initiating causes of the Harlow Hill dam failure were undoubtedly (a) and (b). There was no evidence that the clay had been weakened by base exchange, neither was there any suggestion that the apparently good but actually inferior, drainage system had declined appreciably in efficiency. It appears that rainfall following each drought during the past 80 years, entered the shrinkage cracks and gradually softened the clay fill. The heavy prolonged rainfalls and percolation of the autumn of 1951 was the "last straw." This was aided by several small voids within the fill (due to inadequate compaction), the haphazard presence of fine silts and the contour stone "drain" at the top of the major slip, all of which fed the clay with water at a faster rate than it could drain away. The co-efficient of permeability of some samples of the fill was as low as one ft. per annum, a small rate which was roughly confirmed in practice by drilling two adjacent 10 ft. boreholes. One was filled with water and its neighbour 3 ft. away was left dry, and no flow was recorded between them. The water pressures, and possibly frost, within the shrinkage cracks undoubtedly opened them further and assisted the failure. Several lessons emerged, namely :—

(1) Dams are not age less. They have a limited life, and their factors of safety inevitably decline.

(2) All earth dams of clay constructed before the advent of soil mechanics should be suspect. The unwritten history provides many clues as to the potential stability.

(3) In a homogeneous earth dam with constant batters, that part with the highest embankment has the lowest factor of safety. Few dams, however, are homogeneous.

(4) The "normal" visual inspection of a dam, unsupported by any real knowledge of the properties of the materials of construction, is insufficient to determine the stability of the structure. Visual inspection may be improved by the provision of simple gauges to detect incipient movements.

(5) Soil tests are essential to the determination of actual stability, must be sufficiently numerous to provide a statistical average, and taken from locations on the potential slip planes.

(6) It is possible for soil tests to indicate a safe factor of safety in certain clays during dry weather, when the same material, after prolonged percolation, may have a factor of safety of 1 or less. Either the "normal" factor should be sufficiently high or tests should be taken after a period of severe weather.

(7) Any free draining "material" within an embankment comprised of clay or silts, may either feed and weaken the fill with water, or drain it, depending on its relative position in the structure.

(8) Rectangular reservoirs with the highest part of the embankment at one of the corners, and those with draw-off pipes through the base of the embankment, are potentially the most dangerous.

(9) Clay slips are seldom contiguous.

(10) The size of a reservoir is only one part of the measure of its potential destructive force, The other parts are equally, if not more important, its relative elevation, and what stands in the potential path of destruction.

(11) Every dam should be so sited as to provide ample room for emergency manoeuvres.

—*With acknowledgments to " Civil Engineering & Public Works Review," December 1952.*

QUOTABLE QUOTES

Civil Engineering Looks to the Future

As civil engineers we may well take pride in our profession. We can look to the past with an immense degree of satisfaction, deeply conscious of our heritage—not only of the vast reservoirs of knowledge that have been bequeathed to us, but of the high ideals of public service that have guided our predecessors as, under their stewardship, civil engineering has become the foundation of modern civilization. It is only necessary to consider the modern city—its dependence on highways, railways, airports, water supply systems, sewage disposal systems, hydroelectric power, skyscrapers, and other construction involving structural design—to realize that this statement is not overdrawn. Without these things, cities as we know them could not exist.

Yet our homage to the past does not imply that civil engineering today is in a staid or quiescent state; quite the contrary, it is in the midst of a fundamental evolution. This is a period of transition when empiricism is being set aside for rationalism, when civil engineering is rapidly emerging as a dynamic branch of applied science, heavily dependent on basic science itself and on a wide range of research programmes, many of which are now under way.

What Lies Ahead?

Within recent years this change has been very evident. There has been, for example, the effect of the science of soil mechanics on the more empirical art of foundation engineering, and the impact of fluid mechanics on hydraulic engineering. Still another instance is the recognition of the decree to which progress in sanitary engineering depends on an understanding of basic chemical and biological processes. The manner in which the present era will be evaluated by the civil engineer of tomorrow is to some degree a matter of speculation. However, it seems likely that he will view it as a period most typified by this transition from empiricism to rationalism, a time when the profession made rapid strides under the impact of basic science and research.

* * *

This clarification of function, together with new technological developments, will lead to transportation that is faster, safer, more comfortable, and, most important of all, less expensive. Such transportation will contribute effectively to raising the standard of living, not only because it will reduce the cost of distributing goods, but because better transportation, together with better systems of communication, will make it practicable to coordinate business and industrial activities at locations that are some distance from each other. Thus momentum will be added to the current trend toward decentralisation of our cities with the result that more people can live, work, and play in areas that are less congested. Behind all this, the civil engineer will play the important role of providing the basic ground facilities for all types of transportation, a service so vital that it touches every sphere of human endeavour.

* * *

More Food Will be Needed

Similarly, in considering the future of hydraulic engineering, it is easy to let the imagination run rampant and envisage startling innovations. However, this is scarcely necessary in bringing into focus tomorrow's crucial role for this branch of the profession. We need only to remember that, with a growing population, it will become more and more necessary to grow food under diverse conditions of climate, and that water is the key to this problem. Hydraulic engineers benefiting greatly by advances in aeronautics, oceanography, and meteorology will so

increase their skills that water, one of our most basic natural resources, will be conserved in the true sense; that is, it will be used more wisely in serving the needs of mankind. This will be done in such a manner that topsoil, that thin upper crust of earth on which the food supply of the earth also depends, will be conserved and used, rather than swept into the sea by erosion and floods.

More extensive development of water power, and perhaps the growth of wind power, will also be important in connection with the conservation of natural resources, especially in the conservation of nonrenewable fuels. It appears probable that nuclear power, although it will be available in some locations as a by-product of other operations, is not destined to compete in an important way with power from conventional sources. Its greatest use will be for special applications, often of a military character, where cost is a secondary consideration.

Major advances in sanitary engineering, achieved as a result of basic research in biology and chemistry, will create new methods of treatment that are both more rapid and more economical than those in use today. Speed of treatment will be especially important, since this will lead to much smaller treatment plants which, being less expensive to build, will become economically available to almost every city and town for both water and sewage. Such treatment methods will be equally important in the field of industrial wastes, since plants will be more willing to attack this problem voluntarily, and it will become less necessary to resort to legislative pressure.

In this connection, the reclamation of by-products from industrial wastes, often leading to returns that exceed the cost of treating the wastes, will be a noteworthy factor. The sanitary engineer will without doubt become a key figure in the battle to conserve natural resources—not only by helping to use water more effectively and reclaiming for reuse part of the content of refuse, sewage, and industrial wastes, but by cleaning up lakes and streams, thus leading to larger crops from fish and wildlife, as well as to greatly improved recreational facilities.

Cheaper Structures Foreseen

Structural and foundation engineering will keep pace with the demands of construction, both within and beyond the scope of the civil engineering field. Better methods of analysis and design, ingenious new structural layouts, better use of existing materials, and the almost complete mechanization of prefabrication and erection, all will play their part in reducing construction costs. Decreased cost, of course, is of utmost importance, since more structures can be built with available funds. But perhaps the most spectacular advances in structural engineering will result from the introduction of new and often synthesized construction materials, once again demonstrating the vital role of basic research in civil engineering progress. The treatment of soils with chemical agents so as to change their physical properties is an example of a development that could, conceivably, have far reaching consequences.

Perhaps, in the future, it will not be necessary to adapt structural design to soil conditions as they exist at a given site. It may be that the soil properties needed for a desired type of construction can be obtained by proper methods of chemical treatment, a more positive approch to the science and art of foundation engineering. However, the addition of chemicals is not necessarily limited to soil as a construction material. Possibly the properties of concrete can be modified in an exciting manner—changed, for example, so that much higher tensile stresses and strains can be withstood.

As the writer looks to the future, he would like to think that the fear of atomic warfare will no longer be a major consideration. Although other factors will be of utmost importance if this happy condition is to be brought about, the contribution of the civil engineer is not to be minimized. Hydraulic engineers will do much to increase the power and food supply of the world. Sanitary engineers will play an important part in improving the environment in which people live. Transportation engineers will help to distribute the goods of the world. At the same time, structural and foundation engineers, as the servants of the other three, will do their share by building the structures that make progress possible. All these activities will contribute

directly to a higher standard of living throughout the world, and thus help to remove one of the major causes of war.

Social Considerations Increasingly Vital

There are certain common denominators in the foregoing speculations that deserve special mention, and the first of these is the increasing degree to which social considerations will underlie the planning of civil engineering projects in the future. The conservation of our natural resources, the protection of our people against man-made perils as well as the perils of nature, the betterment of the environment in which they live—these are examples of social objectives toward which civil engineers will direct increasing attention. This does not mean that we do not now have engineers who are socially minded but rather that, in future, civil engineers will have to think more and more in terms of the broad social implications of the projects they build. Inevitably they will have to balance intangible as well as tangible factors in attempting to arrive at solutions that are best "on the whole." Also, they will need to recognize that the rigorous procedure of analysis, important as it is, has its limitations and must sometimes be supplemented with the less formal and partly intuitive procedure of synthesis.

A second common denominator lies in the increasing importance of the basic sciences and of fundamental research. The current transition from empiricism to rationalism promises not only to continue, but to be emphasized. The importance of this trend measured in terms of enabling the civil engineer to render more effective service, has already been strongly suggested. However, there are further implications of tremendous importance to the future of civil engineering, since a profession flourishes in a creative environment.

One of the first realizations that comes to the civil engineer who seeks better ways of doing things in his profession is that the other fields of science and engineering have much to offer in the way of new ideas and new tools. For example, aerodynamics has stimulated hydraulics, colloidal chemistry is helping soil mechanics, and the development of electronics is aid to instrumentation in civil engineering research. Unless an engineer is involved in creative endeavor, he tends to follow the beaten path and this—in spite of the fact that his grave responsibilities are such that he cannot "make haste rapidly"—prevents him from profiting to the full by advancements in other areas.

The world of science is moving at a rapid pace. Herein lies not only the opportunity but the obligation of the civil engineer. We do not know just what advances will be made in the future, but we do know that advances will come. We know, too, that if we are well grounded in fundamentals we are far more likely to recognize the potential value of each advance to civil engineering, and to profit thereby.

Moreover, the birth of each new branch or phase of engineering will create new opportunities for the civil engineer. In the past, for example, aeronautical engineering made the airport necessary. Mechanical engineering, through the motor vehicle, led to the development of traffic specialities. Chemical engineering has created many of our stream pollution problems.

Again, we do not know just what new branches of engineering will create new opportunities for civil engineers in the future, At the moment we might cite nuclear engineering with its attendant problems of structural design and waste disposal, but this is just an example that points the way toward things to come. Whatever the new developments may be, they are potentially fraught with opportunities for the civil engineer, but he must be armed with a fundamental approach to his profession if he, rather than others, is to gain the satisfaction that comes from entering new field of service.

Teamwork Among Specialities

But if we are interested in the new areas of service that are created by other professions, we are even more interested in contributing as a full parener to some of the great advances of science and engineering that the future holds in store. As we examine some of the outstanding achievements of science and engineering during recent years, we cannot help but be impressed, and again the spectacular development of nuclear energy might be cited as an example, by the fact that teamwork between the various specialities not only in science and engineering, but in

industry as well, has been the dominant characteristic. A wide, frontal attack has been involved, in which the rather artificial barriers of strict professional lines have been minimized, or even dissolved. Through co-ordination of activities, each group has contributed its best toward the solution of a problem that was too complex for any one group to handle by itself.

It should be observed, however, that if group are to work together effectively, there must be a common ground on which all can meet. Empircial procedures, necessary as they may be in some instances, do not constitute an ideal base for collaboration. The reduction of procedures to basic elements—to basic science, which serves as a common denominator for all the fields of scientific and engineering endeavour—is far more likely to permit the kind of collaboration that promises to typify the future. This is true regardless of what field of engineering may be under consideration.

Thus research, while helping the civil engineer in his constant effort to serve mankind in his own professional area, serves an even greater purpose than this. It reduces his work to the common denominator of basic science and enables him to work more effiectively as a team-mate with his fellow engineers and scientists.

Earlier in this article it was suggested that tomorrow's civil engineer would view the present era as a period of transition from empiricism to rationalism, a time when the profession made rapid strides under the impact of basic science and research. Now it is further suggested that, as we attempt to appraise the future of civil engineering, the most important possible observation is that the trend now under way will flower. Tomorrow's civil engineer, imbued with an appreciation of research and well grounded in the basic sciences, will operate in a larger sphere that brings him into continued and intimate contact with the other branches of science and engineering, and will thereby open even wider the doors of opportunity for service to mankind.

It is true, of course, that not all civil engineers of the future will be direct participants in creative work. Those who put into practice the new methods that will be developed will always play a most essential role. But it will be those who find better ways of doing things who will blaze the path into the future, and it is on them that we should center our attention. It seems quite likely that future effort in the professional education of civil engineers will be especially focused on these potential leaders. Such a conclusion does not exclude from great importance the sound training of many men for the competent execution of vital tasks that must be carried out with utmost care and skill, but simply recognizes the special contribution to the profession and to society that will come from those who have been endowed with the spark of creative ability.

Three Keys to the Future

Transporatation, water control, and suitable environment, for all of which the civil engineer provides structures and basic ground facilities, underlie every theater of human activity. Essential today, they will be needed even more vitally as civilization becomes more complex. The keys to the future of civil engineering are threefold :—

1. A growing awareness of social values, leading to sounder planning.
2. An increasing emphasis on fundamental research, leading to better design.
3. The wiser management of men and equipment, leading to better methods of construction.

Of these three keys, research is the most important, for only by extending the boundaries of knowledge can a profession maintain its stature, and forge its way to the new frontiers that always lie ahead.

With acknowledgments to "Civil Engineering," September 1952.

NEWS ROUND-UP

New Tension-Type Sluice Gate.

Intended Primarily for Open Channel Work, The Bowtell Design Offers Considerable Savings in Weight, Cost and Maintenance

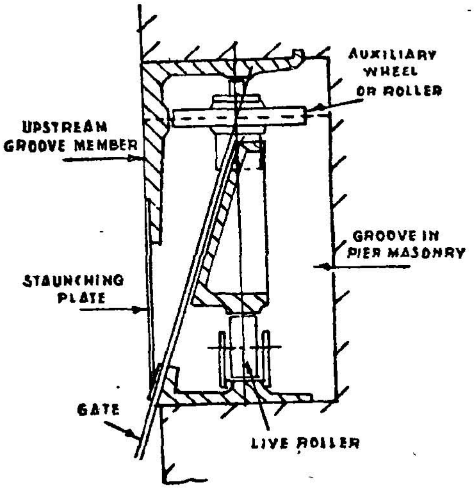
An entirely new type of sluice gate designed by Mr. W. J. Bowtell and possessing several interesting features is being manufactured by Head, Wrightson and Co., Ltd., Thornaby on-Tees. It has definite advantages over a normal type of gate in certain applications.

The Bowtell gate is designed as a shell in tension and may be made from plates of steel or aluminium alloy into the form of a segment of a cylinder with its concave surface facing up-stream. The water load on the gate is transmitted to grooves in the piers or abutments by trains of rollers or, in the case of small gates, by wheels. The gate ends are fitted with vertical beams which bear upon the rollers giving continuous support along their length. The gate, therefore, is practically entirely in tension, the water pressure tending to retain it in its correct form.

Compared with a gate of similar width of opening and depth, the Bowtell design has a larger surface area, but because it does not have to be reinforced against bending a considerable saving in weight can be attained. When steel is used for the construction the large sizes of gates are little more than half the weight of comparable gates of normal design. Further weight reduction is made possible by the use of aluminium alloy, a material which is particularly suitable for this pattern; this in turn leads to less need for counterbalancing.

Very little stiffening is required beyond an angle or flat bar along the top and bottom edges, whilst joints on the plates need only flat bar covers. In the case of the larger gates an occasional vertical stiffening angle may be attached. There are therefore no girders on which silt and organic matter can accumulate—an important consideration in certain circumstances. Further, the generally clean design makes all parts easily accessible for cleaning and painting.

The bottom of the gate closes on to a curved metal sill built into the floor of the sluice way, and, where a high degree of watertightness is needed, a rubber strip is fitted to bear upon



the sill. Because of the curved shape simple greenheart sill cannot be used.

Originally, the design incorporated full semi-cylindrical gates, and three of this type have been installed in Britain. In the latest model of the gate subtends an angle of only 145 degrees, resulting in a saving of material, and allowing simpler pier design and construction. Six gates of the latest form are at present being built for a drainage scheme in Trinidad. They are of 5/16-in aluminium alloy, with 25 ft. width of opening are 7 ft. in depth and have a 9-ft. lift.

Where the gate end enters a grove an end beam is connected to the tangential extension of the gate plates. The water load on the gate is transmitted through live rollers to the grove. As the rollers are offset to the gate, a turning moment is produced which is balanced by auxiliary wheels carried by the end beam and bearing on a steel member connected to the upstream face of the groove. The load on these wheels in about 30 per cent. of that on the rollers.

The load from the auxiliary wheels produces a bending moment on the groove member, but this is largely, or even completely, balanced by by the pressure of the water on its outside face.

A feature of the design is the almost complete elimination of eddies causing roller vibration when the gate is partly open. This is achieved by largely enclosing the groove by a staunching plate attached to the upstream groove member—resulting in a very narrow opening of the groove facing down-stream.

Certain detail variations are available according to the size and purpose of the gate. For instance, wheels may be used in place of the live rollers in certain cases where pressures are not high. In very small gates the auxiliary wheels may be omitted, the end beam being modified to bear frictionally on to the upstream groove member. The staunching plate may be fitted with a flexible end strip where heavy loads are likely.

There are, of course, limitation to the use of this type of gate, as it is not designed to withstand any considerable load in the reverse direction, but it is eminently suitable for open channels such as rivers and canals. The gate can be reinforced to meet small reverse loads and, in the case of the Trinidad gates, rolled joists have been added to take small tidal reverse pressures.

Operation of the gates can be by rope and pulley or by rack and pinion. Provision can be made for manual or electrical operation.

"*The Overseas Engineer,*" *August 1952.*

* * *

Tips on the Best use of Your Concrete Vibrators

Vibration itself does not directly improve the quality of concrete. The advantages of vibration are gained indirectly by the changes that can be made in the concrete mix.

Concrete mixtures include coarse aggregate fine aggregate, cement and water, and the ratio of these ingredients in the mix is varied as to the results desired. It is through the changing of these ratios that the benefits of a concrete vibrator are obtained.

As the concrete mixture dries or sets, most of the water hydrates with the cement, while the remainder evaporates. Examination of concrete walls after the forms have been removed often shows the surface containing numerous small voids. These voids are caused by the evaporation of the water as the concrete sets up. Elimination, or at least reduction in these voids can be accomplished by cutting down the amount of water in the mixture until it will all hydrate with the cement as it dries. However when this is done the mixture becomes so stiff that it is difficult to place in the forms. In fact, it is impossible to place in the forms. In fact, it is impossible to place such a mixture by hand methods. This is where the concrete vibrator comes into play ; regardless of how stiff the batch, it can be efficiently placed with a vibrator.

Concrete can be made much stronger through the use of vibration, and the mixture can also be made cheaper by cutting down the cement content. Since harsh batches can be

placed with a vibrator it is possible to increase the amount of coarse aggregate and decrease the amount of fine aggregate. There is not as much area to be coated with mortar, and this enables us to cut down the cement content. In increasing the density of the concrete structure to obtain additional strength, greater water-tightness is secured also, which in building construction is of tremendous importance.

Benefits for the Contractor

First, placing costs are reduced, as one man with a vibrator can replace from three to eight puddlers. This is in itself quite an item, with labour costs at their present level. Second, drier concrete cuts evaporation and there will be fewer voids on the surface of the finished wall, thus reducing finishing costs. Third, the mixture being placed drier, sets up more quickly making it possible to remove the forms sooner, and move them to another location on the job. This of course cuts down the investment in forms for the job. Fourth, the job progresses faster, thereby eliminating penalties for failure to finish on schedule. Fifth, the concrete being drier escapes damage from frost more quickly when work is being done in freezing weather. This serves to cut down heating costs.

Concrete vibrators, like all other tools, must be properly applied to the job for which they were intended. And in some cases it may be necessary to alter the job to make it fit the vibrator.

How far do the vibrations carry through the concrete? This is a hard question to answer, since the slump will govern to a certain degree the distance to which the vibrations will carry. The best way to answer this question is to tell how to determine on any particular job how far out the vibrations are reaching. Of course, reason for asking this question in the first place is to find out how far to move the vibrator each time.

It will be noted after the vibrator has been in the concrete a short time that the mixture forms a plastic mass. This area will extend for a certain distance around the vibrator, so that all that it necessary is to move the vibrator a distance equal to the diameter of the area which it has affected. This distance will vary depending on the slump of the concrete.

Where? How long?

Vibrating can be carried on with a disregard for the reinforcing bars as far as moving distances are concerned, since the vibrations will carry through and around the bars. For example, if a wall 18 in. in width is being vibrated, and steel is placed from 2 to 4 in. from each face, it is only necessary to vibrate in the middle of the wall. It is not necessary to insert the vibrator between reinforcing bars and forms.

After it has been determined how far to move the vibrator each time, the question arises. how long should the vibrator be left submerged in the concrete before it is moved? Here again a variable is involved in that the lower the slump, the longer the vibrator should be left in the same spot. The way to determine the length of time to vibrate properly is to watch the mass surrounding the vibrator. As soon as the mixture forms a plastic mass the vibrating head should be moved.

Care should be taken not to overvibrate, that is to leave the vibrating head too long in one place. This practice will tend to cause separation of the aggregate. The manner in which over vibration can be detected is by noting closely the area adjacent to the vibrating head. When an excessive amount of mortar appears close to the vibrator or when there is a marked absence of mortar, it is indicative that over-vibration has occurred. Therefore, the rule to follow in operating the vibrator is to vibrate in one place only such time as is required for the vibrator to form a plastic mass.

When a wall is being poured in lifts, extreme caution should be exercised to prevent the vibrating head penetrating into lower lifts which have already been vibrated. Since this mass will have already taken its initial set, additional vibration will do more harm than good. This unneeessary vibrating will also cut down the production of the vibrating unit.

Rules For Mass Concrete

Although this discussion has dealt primarily with the vibration of walls, the rules for successful operation of a vibrating unit in dams, piers,

columns, slabs, etc., are practically the same. With the exception of thin slabs measuring from 4 to 10 in. in thickness it is good practice to lay the vibrator down and simply drag it slowly through the mass. Lifts of any depth can be vibrated satisfactorily since the vibrating unit can be completely submerged in the mass. No harm will result from following this practice, as the core and casing are fastened to the vibrating head in such a manner that it is impossible for foreign materials to enter. The outside of the casing is rubber which protects the inner structure from water and other substance with which the unit comes in contact.

" *Western Construction*" *October, 1951.*

* * * *

Qualification of a Research Worker

According to an interesting article the Chief qualifications required of a research worker are :—

		Relative value.
(1)	Interest ...	5
(2)	Open mindedness ...	10
(3)	Breadth of view ...	15
(4)	Imagination ...	30
(5)	Judgement ...	15
(6)	Technical knowledge ...	10
(7)	Experience ...	10
and (8)	Responsibility ...	5
	Total ...	100

"(1) Knowledge in both the subject and object of the research, comes first because, without interest, perseverance is discouraged and all other qualifications lack stimulus for their optimum exercise.

"(2) Open minded-ness comes next because if prejudice be present, all things will be viewed, in the light of that prejudice and the result will be vitiated.

"(3) Breadth of view is necessary because without it, factors, not obvious, but having an important bearing may be omitted from consideration, and again result would be vitiated.

"(4) Imagination is needed, because without it, no new thing is discovered. Chance may take its place. But what reliability has to be placed upon chance? And even with chance generally an imaginative mind is needed to sieze the opening which chance provides.

"(5) Judgment is needed because, what should and what should not be done has frequently to be decided, and decision without judgment is valueless.

"(6) Technical knowledge is clearly an advantage. But no individual's knowledge is universal, and lack of particular knowledge can be made up by knowledge of where particular knowledge is to be found. In days of reference books and consultative specialists, absence of special knowledge in an individual can be remedied.

"(7) Experience of the subject of the research is useful and it is the more useful the shorter is the time available for research. But in any long term research experience is a poor offset to lack of other qualifications.

"(8) Responsibility, *i.e.*, sense of responsibility to truth, is very necessary. Special pleading, concealment of essential fact, or glossing of adverse argument, all lead to multification of purpose. And the purpose, of research is truth".

(Extract from the Central Board of Irrigation Journal—July 1946 page 208).

Undisturbed Sampling of Earth Materials

Hand-Cut Samples

Sampling by hand methods including block, cylinder, and chunk samples is suited to all types of soil material and is only limited by accessibility. Hand-cut samples can generally be obtained with less disturbance than samples procured by other methods; in addition, the representative strata can usually be selected prior to sampling. Sampling is accomplished by cutting and trimming away material surrounding any portion of the stratum which has been selected as a sample. Small shovels, knives, chisels, spoons, and hacksaw blades are used in cutting and removing the surrounding soil from the sample. The illustrations, shown in the opposite page, are examples of these operations.

Cutting and trimming block samples to the desired size and shape is tedious, particularly when working with easily disturbed soft or blocky material. The gratest danger in breaking the sample occurs when it is cut free and lifted for removal. As the sample is progressively trimmed to the desired size, it should preferably be painted with warm liquid paraffin and then wrapped with a cloth and again pointed with liquid paraffin. The sealing jacket thus made will reinforce the sample against disturbance and will also reduce moisture losses during and after the cutting period. After the sample has been cut to proper pedestal size and sealed as described above, a reinforcing box or several sacks should be placed over the sample to stiffen and cradle it before the pedestal is cut off and the sample lifted for removal. Hand-cut block samples should be 1-foot cubes unless other sizes are specifically requested. All laboratory specimens usually required for testing can be cut from such a sample.

Cylinder samples of 6-inch diameter by 12-inch length are often easier to cut and remove without disturbance. Galvanized metal cylinders with open ends provide good trimming guides and sealing containers when the ends are sealed with paraffin. See figure 40 for illustrated procedure for cylindrical samples.

All samples should be marked *top* and *bottom* before removal to avoid confusion and possible reversing in the laboratory. Also, all samples should be labelled with the hole number, project, feature, and elevation or depths between which the sample was taken.

Note:—When " warm liquid paraffin " is applied to a soil sample, it should be handled in such a manner that paraffin does not penetrate the sample. Penetration may be prevented by painting thin layers of paraffin that will congeal rapidly over the sample or by wrapping cloth around the sample before the paraffin is applied.

With Acknowledgments to "Earth Manual," Published by United States Department of the Interior, Bureau of Reclamation, Denver.

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AUTOMATIC CONTROL OF IRRIGATION SYSTEM

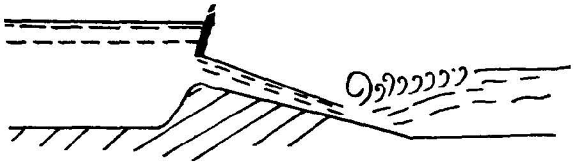


FIG. 1. MODULE

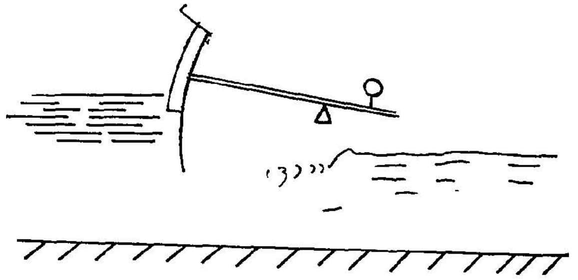


FIG. 2.

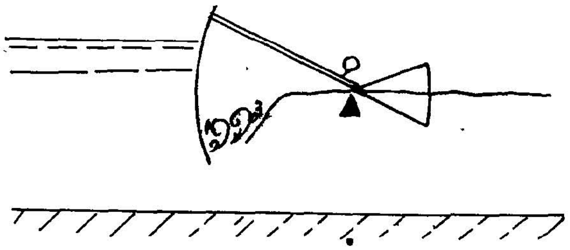


FIG. 3.

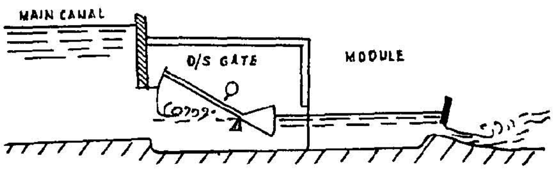


FIG. 4. INTAKE TO LATERAL CANAL

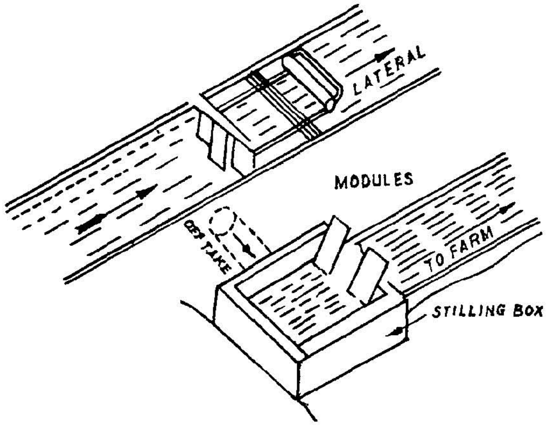


FIG. 5 - AUTOMATIC IRRIGATION WITH UPSTREAM CONTROL

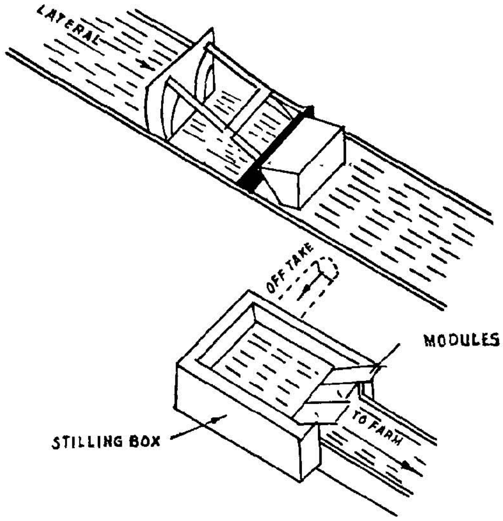


FIG. 6 - AUTOMATIC IRRIGATION WITH DOWNSTREAM CONTROL

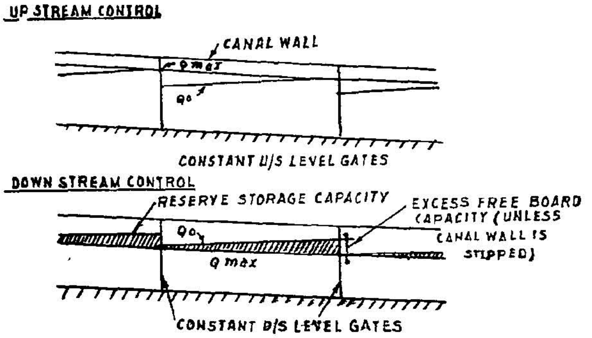


FIG. 7 - COMPARISON OF TWO SYSTEMS.

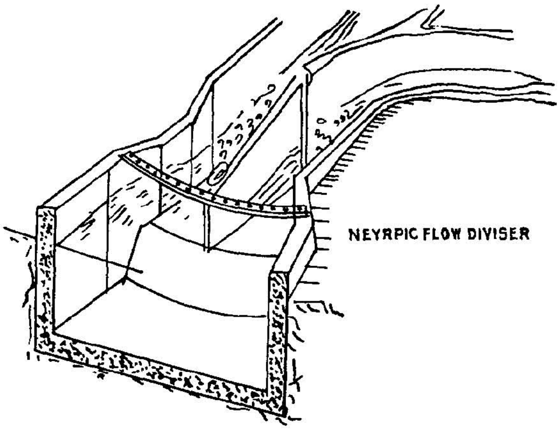
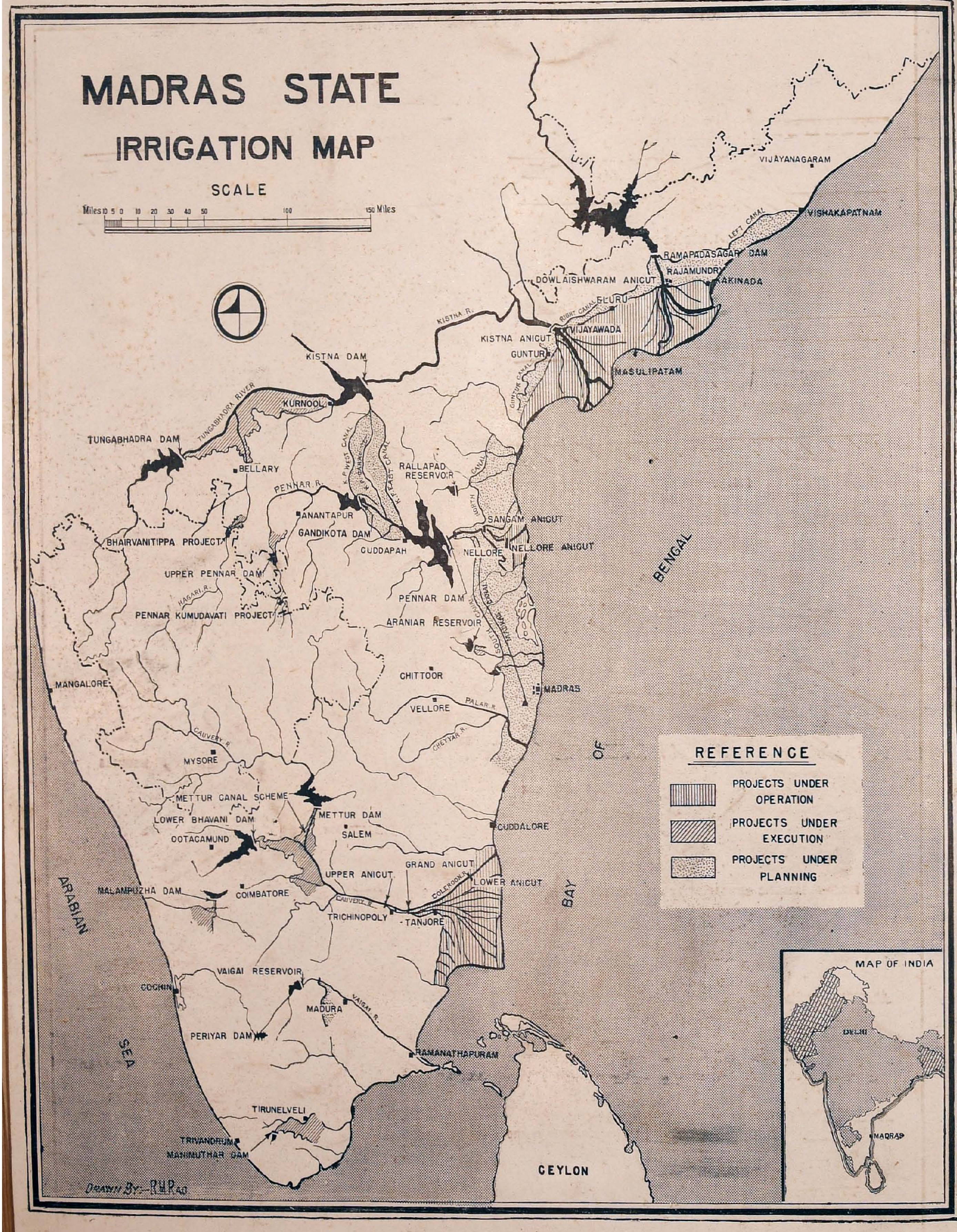


FIG. 8.



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